AD-A124 188 ALTERNATIVE ANALYSIS TECHNIQUES FOR NEEDS AND NEEDS DOCUMENTATION TECHNIQUES(U) BATTELLE COLUMBUS LABS OH J D HILL 20 JUN 80 F33600-80-C-0414 1/1

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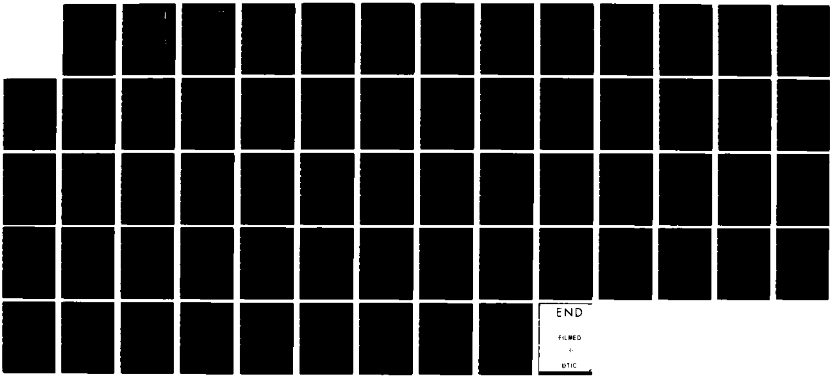

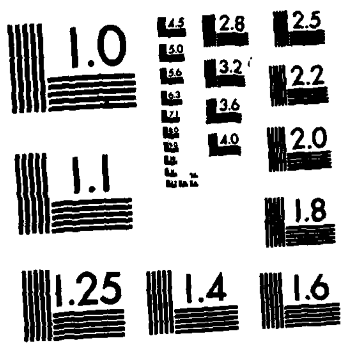


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II

LEVEL

INVENTORY

Task $5(b)_N$ and $5(c)_N$: Alternative Analysis Techniques for Needs ~~and Needs Documentation~~ Documentation Techniques

DOCUMENT IDENTIFICATION

Contract F33600-80-C-0414 20 Jun. 80

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June 20, 1980

Mr. Coye Bridges, XRBF
DCS/Plans and Programs
Air Force Logistics Command
Wright-Patterson AFB, OH 45433

Dear Coye:

Reference Contract No. F33600-80-C-0414

Enclosed are two deliverables due seven weeks after contract award. The related task and title of each deliverable are as follows:

| Task | Deliverable |
|---|---|
| Task $5(b)_N$ | Alternative Analysis Techniques for Needs |
| Task $5(c)_N$ | Alternative Needs Documentation Techniques |

You will note that both deliverables have been combined into one document because of their tight coupling.

Also enclosed are:

1. A list of "High Level Guidance Items" that have been extracted from various USAF documents and which can be used to augment the scenarios.
2. "Descriptors that will be Important Drivers in the Proposed Scenarios" (addendum to Task 4(b)).
3. "Stimulating Topics for the Back Pocket" which list some topics (to be augmented by Maj. A. Dunn) that may be brought up as appropriate during planning sessions.

4. Revised Task $5(a)_N$ deliverable that now includes the LMS concept description.

Please let me know if we need to get together to discuss the deliverables.

Sincerely,

J. Douglas Hill
Research Leader
Defense Systems & Technology Section

JDH:eah

Enc.

# TASK 5(b)$_N$ AND 5(c)$_N$: ALTERNATIVE ANALYSIS TECHNIQUES FOR NEEDS AND NEEDS DOCUMENTATION TECHNIQUES

It is impractical to separate the analysis techniques and the documentation methods to be used in analyzing the session content. Most analysis techniques have an inherent recording method which is most suitable for maintaining an audit trail. Therefore, we will combine the reporting of these items in the same paper.

## Policy Planning Session

### Analysis and Documentation of Scenarios

The Theme Scenarios being developed basically describe the environment within which the War Scenarios may occur. It is likely that these themes will influence the probability of the occurrence of a given war scenario, e.g. a condition of high availability of alternative fuels will decrease the probability of a conflict over Mid-East oil resources. At this stage in the development of the planning process, we will not attempt to quantify these relationships, but merely acknowledge their existence. Further refinements of the scenarios may be based on the quantification of probabilities.

At this point, however, the primary concern is to identify the relationships between scenario drivers/descriptors and their impact on the Logistics Management System.

To obtain usable information from this process it will be necessary

1. To describe the initial condition of the scenarios in enough detail that impacts can be consistently identified
2. To structure the ability to change the scenarios as they become further defined through the planning process.

   The changes may include:

   - Additions of driver/description;
   - Changes in arrows or signs or;
   - Elimination of descriptors determined to be non-relevant.

In order to establish the initial description and an audit trail for change, a coding system is being developed. The tentative selection is an

alpha-numeric value assigned to each descriptor in the initial scenarios. This identifier would refer to the theme scenarios involved, the war scenarios being considered, the class of descriptor, and numeric identifier for the individual descriptors.

There are three theme scenarios, which also will have titles, but will be referred to as A, B, or C. The war scenarios will be 1-4. There are five classes of descriptors.

| | |
|---|---|
| Geo-political and International Economics | (IE) |
| Military | (MI) |
| US Economy | (UE) |
| Social | (SO) |
| Demographic | (DE) |

The descriptors will be numbered consecutively within their respective groups, e.g. IE1, IE15; UE1, UE18. Sample codes are shown in Figure 1.

A1MI4

A - Theme Scenario A

1 - 1st War Scenario

MI - Military area

4 - Consecutive number

FIGURE 1. SAMPLE CODE

As the scenarios evolve throughout the planning process, it is very likely that some simplification will occur. At present, the relationships between the drivers, (exogenous variables being used to drive the scenarios) and the internal variables or descriptors are being developed so that impacts on the logistics functions can be defined and logistics management information needs determined. In the process of deriving the impacts' logic trail the key drivers should be identified, and associated directly with the impacts. The techniques, to be used with the scenarios, include:

1. The cognitive map, which displays the relationships between scenario elements, by means of an arrow to establish the direction, a plus sign to signify a direct relationship, and a minus sign to signify an inverse relationship. The net effect of several events reacting on another descriptor is indicated by the use of a delta ($\Delta$) with an arrow indicating a net increase ($\Delta\uparrow$), a net decrease ($\Delta\downarrow$), or relative stability ($\Delta\rightarrow$).

arrow indicating a net increase ($\Delta\uparrow$), a net decrease ($\Delta\downarrow$), or relative stability ($\Delta\rightarrow$).

These symbols also will be used in a tabular form to demonstrate the common areas of the various scenarios, and conversely, the areas of change.

2. The coding system, which consists of the alpha-numeric identifier previously described. A log will be maintained for each descriptor which will include: a title, a brief description of what it is intended to include, the code assigned, the direct links established to other descriptors, along with the direction and sign, and a record of changes.

This will all be done manually in the initial stages of the project. As the planning process evolves, it may prove necessary to automate the maintenance of these files to allow the tracing of paths through the scenarios by merely identifying the driver. This would involve a networking technique. This is not recommended at this time due to the evolutionary nature of the planning effort. We expect, as we mentioned earlier, that the scenarios may be simplified, and manual maintenance may remain adequate.

3. A cross impact analysis may be used if the scenarios evolves to the simplified level. It is not recommended at this time.

## Analysis and Documentation of the Impact of the Scenarios on AFLC Process/Perspectives

Once the scenarios have been adequately described, the next step will be the identification of their impacts on the processes and perspectives. In order to record these impacts, a matrix will be developed with one axis being the level of management and the second being the processes and perspectives.

A partial sample record is displayed in Figure 2.

During the sessions, the recorder selected will note the impacts defined by putting a few key words in the appropriate section of the matrix which will be displayed on easels. This display will serve as a guide in the session, and be used to present the findings of the smaller groups to the complete group. In each of the smaller groups, an observer will be present to note the descriptor code and to make relevant notes concerning the derivation of these

| Logistics Process / Management Level | Plan/Program/Budget | Requirements |
|---|---|---|
| Strategic | | (A1 UE4)<br>Change a parametric models required to reflect. . . . |
| Directive | (A1 U14)<br>Increase inflation reduced funds in POM available. Reallocate | |
| Operational | | (B3MI5)<br>Emphases in numbers instead of sophisti-cation means hi volume in low skill area |

FIGURE 2. SAMPLE IMPACT MATRIX
(Partial matrix only)

impacts, e.g. background discussion, related areas, etc. The observer also will be responsible for identifying the specific descriptor if the recorder fails to do so. After each sesson, the observer's notes will be edited and typed and added to a log of proceedings. Key elements will be extracted and summarized, to be presented to the participants for approval. This summarized edition of the proceedings for each session will serve as the input for the succeeding sessions.

The recorded information will be sorted using the identifier code, so that impacts will be aligned by: War scenarios, theme scenario, and process/perspective.

This cross tabulation will allow the development of a synopsis of the impact of a given scenario, and the information needs required by a given process.

## Needs Planning Session

### Analysis and Documentation of Scenarios

The same technique described in the Policy Planning Section will be continued in the Needs Planning Session. One additional piece of information will be tracked, however, and that will be any changes suggested in the second session.

New impacts or suggested changes identified will be listed separately, and reviewed for inclusion in the formal documentation.

### Analysis and Documentation of the Scenarios on AFLC Processes/ Perspectives

The approved results of the first session will be presented to the Needs session. The first objective of this review is to elicit agreement that the impacts are adequately and correctly identified. The second objective is to realign the impacts that are associated with the particular topics and associated LAG(s) under discussion. Since the LAG(s) can cross both management levels and processes, it will be necessary to identify the impacts related to the LAG, and identify crossovers with other LAGs. In some cases the further division into logic clusters will be necessary in order to arrive at viable units for further analysis.

In order to document and control the planning process, it will be necessary to designate an orderly flow of information from one planning segment to the next. This requires the careful identification of the inputs required for each segment, the expected transformations, the desired outputs, and the controls and mechanisms for effecting this transformation.

Successful planning also requires effective communications with all involved in the planning process. The IDEF model is a recommended candidate because it can serve three functions. It serves as:

- o A graphic portrayal of the functions (performed by man or machines) and things (objects or information) which constitute the logistics system.

- o A hierarchical structure with major functions at the top and successive levels revealing well-founded details.

- o A communication device to allow review of the developing model and a record of all decisions in writing. Consistent portrayal and terminology is used throughout to facilitate precise transfer of information.

IDEF is a system requirements definition technique which provides training for Architecture Builders, Information Model Builders, and User Model Builders. It was developed by SofTech, Inc. for the USAF programm for Integrated Computer-Aided Manufacturing (ICAM). This version is based on an underlying discipline, called "structured analysis". (Ross, "Structured Analysis (SA): A Language for Communicating Ideas", IEEE Transactions on Software Engineering, 3, 1, January 77).

Structured analysis is a graphic language for describing any system. By system, we mean both what something is and what it does. A structured analysis model simply describes that tangible or functional reality.

Man-made systems are composed of interacting or interdependent parts that work together to perform a useful function. The parts may be anything, including machinery (hardware), information, objects, processes, software, or people. These systems are, universally, composed of things (parts)

that perform activities that act on other things (objects or information). Structured analysis can be used to describe activities performed by systems or parts of systems.

Structured analysis represents a system by way of a model composed of diagrams. Diagrams are composed simply of boxes and arrows. To describe functions, activity diagrams are used. In these diagrams, the boxes represent activities and arrows represent things processed by the system. By "things", we mean anything -- any kind of data that can be named with a noun, from tangible objects to abstract information.

IDEF starts by representing the whole system as a single modular unit -- a box with arrow interfaces. Since the single box represents the system as a whole, the descriptive name written in the box must be general, rather abstract, and lacking in detail. The same is true of the interface arrows, since they also represent the complete set of external interfaces to the system as a whole.

The box that represents the system as a single module is then detailed on another diagram with several boxes connected by interface arrows. These interconnections make the boxes represent major submodules of the single parent module. The decomposition reveals a complete set of submodules, each represented as a box whose boundaries are defined by the interface arrows. Each of these submodule boxes may be similarly decomposed to expose even more detail.

IDEF provides rules covering how to gradually introduce further detail during decomposition. A module is always divided into no fewer than three, but no more than six submodules. The upper limit of six forces the use of a hierarchy to describe complex subjects. The lower limit of three was chosen to insure that enough detail is introduced to make the decomposition of interest.

Each diagram in a model is shown in precise relationship to other diagrams by means of interconnecting arrows. When a module is decomposed into submodules, the interfaces between the submodules are shown as arrows. The name of each submodule box plus its labeled interfaces define a bounded context for the detailing of that submodule.

In all cases, every submodule is restricted to contain only those elements that lie within the scope of its parent module. Further, the module cannot omit any elements. Thus, as already indicated, the parent box and its interfaces provide a context. Nothing may be added or removed from this precise boundary.

Figure 3 demonstrates the relationship between the components.

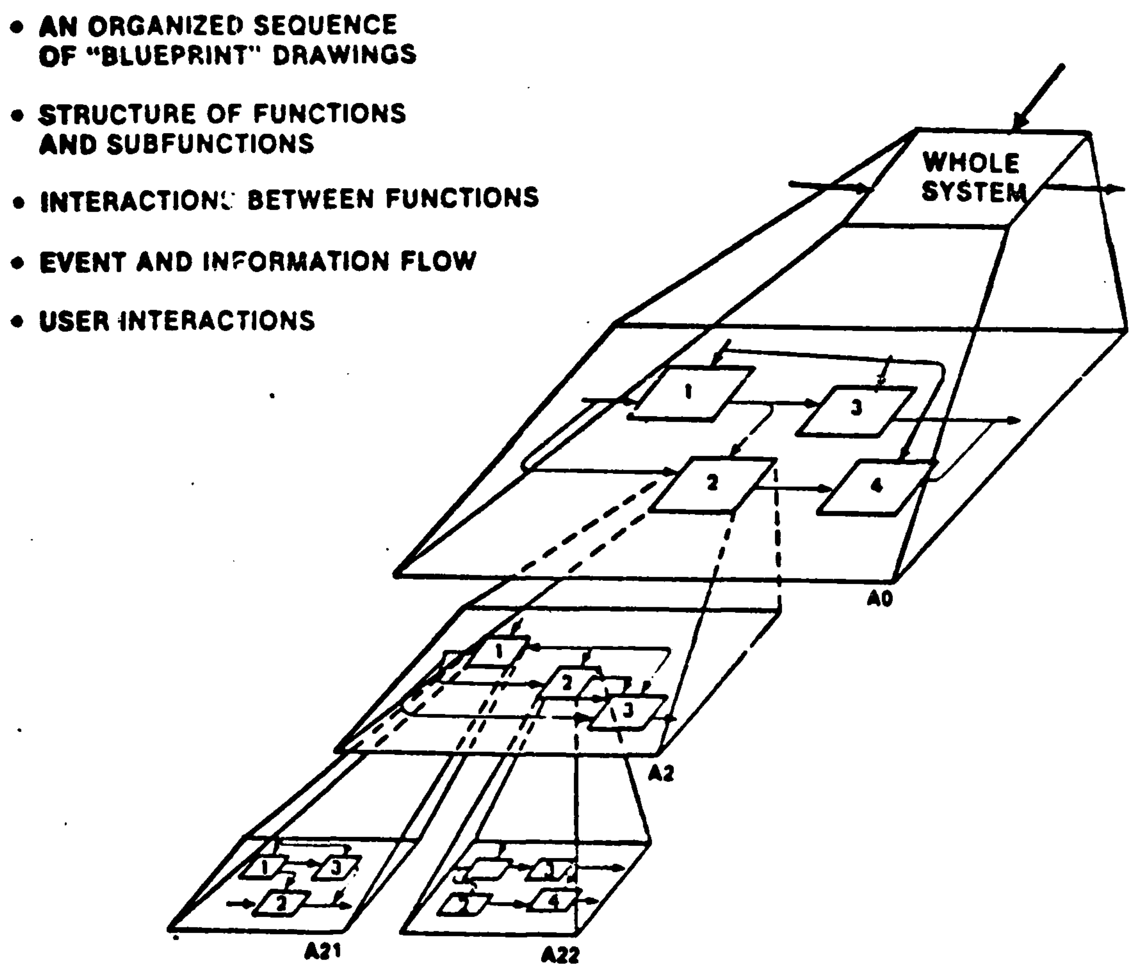



FIGURE 3. RELATIONSHIP BETWEEN COMPONENTS USING IDEF

Further information on the IDEF system is contained in Appendix A.

An alternative documentation technique that provides a hierarchical graphic structure for portraying logic trails, discussion trails and for plugging them into logical relationships is the relevance tree.

## Relevance Tree

The relevance tree is normally structured in levels. Each level may represent a certain class of vertex entries. Connection from one level to another is based upon the relevance of one class of entries to another class of entries. The relevance tree is usually a hybrid tree.

Generally, the broader classes are presented at the top of a relevance tree, with the highly specific classes being represented at the bottom of a tree. For example, the highest level may represent a very broad problem to be solved. The next highest level may represent constituents of the environment. Down at the very bottom of the tree might be specific technological developments that could contribute to the solution of the broad problem, such as a means of removing sulphur from coal to assist in alleviating air pollution.

An example of a relevance tree appears in Figure 4. Its hybrid character is evident from the nature of the items.

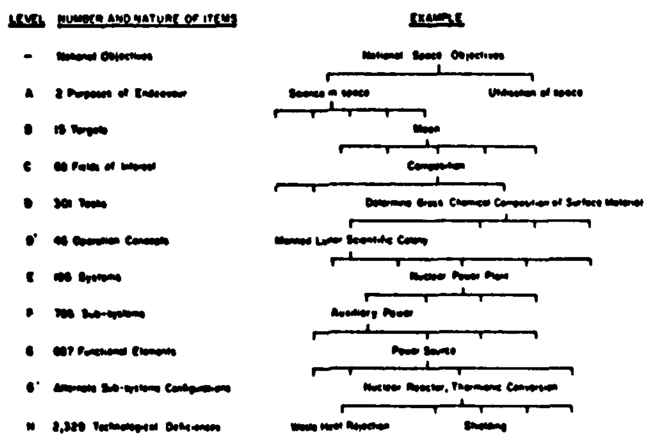



FIGURE 4. NASA'S APOLLO PAYLOAD EVALUATION RELEVANCE TREE

A more detailed discussion of relevance trees is contained in a paper in Appendix B.

The first diagrams, whether IDEF structures or Relevance trees, will be produced as a result of the input from the Needs Planning Sessions. Draft versions will be produced and distributed to selected planning participants for review and comment. All comments must be in writing and all response to comments must be written in the same copy. Suggestions are accepted or rejected in writing along with the reasoning used.

As mentioned earlier in this report, the IDEF method has been developed for Air Force use. Courses in the method have been offered regularly through the ICAM office. Courses to individuals requesting them have been offered at a cost of approximately $1000/student plus instructors expenses for a four-day workshop with a minimum of six students/class. Students attending these through ICAM pay only for expenses.

It would be necessary to train authors and readers in each LAG area as it was being analyzed. Transfer of documents for reader comments can be done through the use of the Cybernet system using a program called AUTO-IDEF. Use of this capability would not be a requirement.

The model outlined in this report is the IDEF-0 model, which identifies functions. The IDEF-1 model is the information model, which identifies the data base lay-out required for each area analyzed. The IDEF-2 model is the dynamics model which treats with time-oriented behaviors and allows the construction of simulations.

All three models currently are available, ahtough their development is continuing.

## Relationship Between Needs Identified and LMS Principles

The analysis of the Needs identified in the planning sessions must be tempered by the application of the LMS principles. These are being derived from:

- o Air Force Doctrine
- o Logistics Principles
- o Management Science Principles

- Information Management Principles
- Government Policy/Law.

These constraints are being used to identify areas, and principles relating to each. As the Needs Identification progresses, it will be necessary to use these as a guiding mechanism to insure good practice in defining systems to be developed to meet these needs. These principles will help identify the scope of information needed to adequately define the needs. Therefore, a checklist of information to adequately define the Need will be generated, based on the principles identified.

For example:

Area: Privacy and Security Access/Control

Principle: Systems must be compatible with, and should support any necessary security requirements.

Check List: Security Requirements identified.

## Planning Participant Reaction

Obtaining participant reaction to the format of the planning sessions and planning techniques used is an essential part of the analysis procedure. Some of this reaction will be obtained through casual comment and conversations and these will be documented as relevant. Another measure of satisfaction will be the willingness of the planners to contribute to future planning sessions either in person or by sending their best staff members. We will compare "who is requested" with "who shows up".

These indirect measures will be complemented by two questionnaires designed to assess participant satisfaction with the planning sessions. One will be administered at the beginning of the first morning session and the second will be administered on the last afternoon. They are designed to measure both general satisfaction and satisfaction with the group planning techniques. Copies of the questionnaires are contained in Appendix C.

# APPENDIX A

## IDEF DESCRIPTIVE MATERIAL

## STANDARD DIAGRAM FORM

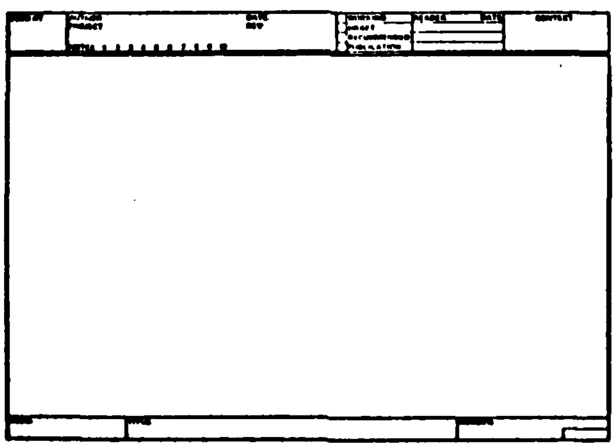
The entire discipline of structured analysis depends on a single form - the Diagram Form - and that form has minimum structure and constraints. Other than name and date information that would be expected for any form, the sheet supports only the functions important to the discipline. They are:

- Establishment of context;
- Cross-referencing between pieces of paper;
- Notes about the content of each sheet.

The diagram form is a single standard size for ease of filing and copying. The form is divided into three major sections:

- Working Information (top)
- Message Field (center)
- Identification Fields (bottom)

The form is designed so that, when a final, "approved for publication" version is completed, the working information at the top of the form may be cut off. The diagram form should be used for everything written, from rough notes through sketches to finished diagrams and texts. (Note: when using a diagram form, always fill in the "Number" and "Author/Date/Project" fields first, before actually using the form. These fields are explained in this section.)



## 4.1 Working Information

### The "Author/Date/Project" Field

These tell who originally created the diagram, the date that it was first drawn, and the project title under which it was created. The "date" field may contain additional dates, written below the original date. These dates represent revisions to the original sheet. If a sheet is re-released without any change, then no revision date is added.

### The "Notes" Field

This provides a check-off of notes written on the diagram sheet. It ensures that the next higher note number is assigned without scanning the sheet to find all previous notes. The notes themselves are called "(n) notes," and are of the form:

"(n) message"

where the "n" is the note number, assigned sequentially on each diagram sheet by the person making the note. The "message" portion is any comment made by a reader (or author) about the diagram. Information which is part of the basic diagram itself is not an (n) note, and does not contain the "(n)" prefix.

### The "Status" Field

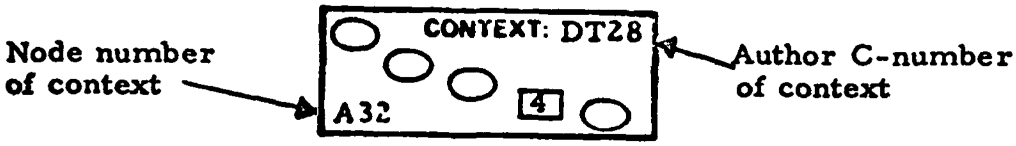
The status classifications provide a coarse ranking of approval. They are:

| | |
|---|---|
| WORKING | The diagram is a major change, regardless of the previous status. New diagrams are, of course, working copy. |
| DRAFT | The diagram is a minor change from the previous diagram, and has reached some agreed-upon level of acceptance by a set of readers. Draft diagrams are those proposed by a task leader, but not yet accepted by a review meeting of the technical committee or coalition. |
| RECOMMENDED | Both this diagram and its supporting text have been reviewed and approved by a meeting of the technical committee or coalition, and this diagram is not expected to change. |
| PUBLICATION | This page may be forwarded as is for final printing and publication. |

The "Reader/Date" area is for a commenter to initial and date the form.

### The "Context" Field*

This indicates explicitly the context in which the diagram form is to be interpreted, even if it is used for non-diagram purposes. The context sketch always is at the next higher level from the current diagram. The sketch normally shows only as much as is needed to make the context clear. The current diagram is shown as a box in the sketch, to highlight it; all other parts of the higher level are drawn as ovals. Arrows are omitted. The C-number of the higher level diagram is written at the top of the Context field, and the node number in the lower left.




The Context field of a context diagram (node number - 0) is "NONE." The Context field of a top level diagram (node number 0) is "TOP."

### The "Used At" Field*

This is a list of diagrams, other than the immediate context, which use this sheet to show details. These may include the work of several authors.

## 4.2 The "Message" Field

The Message field contains the primary message to be conveyed. The field is normally used for diagramming. However, the field can be used for any purpose. This freedom is essential, for otherwise the author would have no place to keep definitions, checklists, notes, sketches, etc. The author should use no paper other than diagram forms. Conventions allow complete reconstruction of his thought process in doing the work.

---

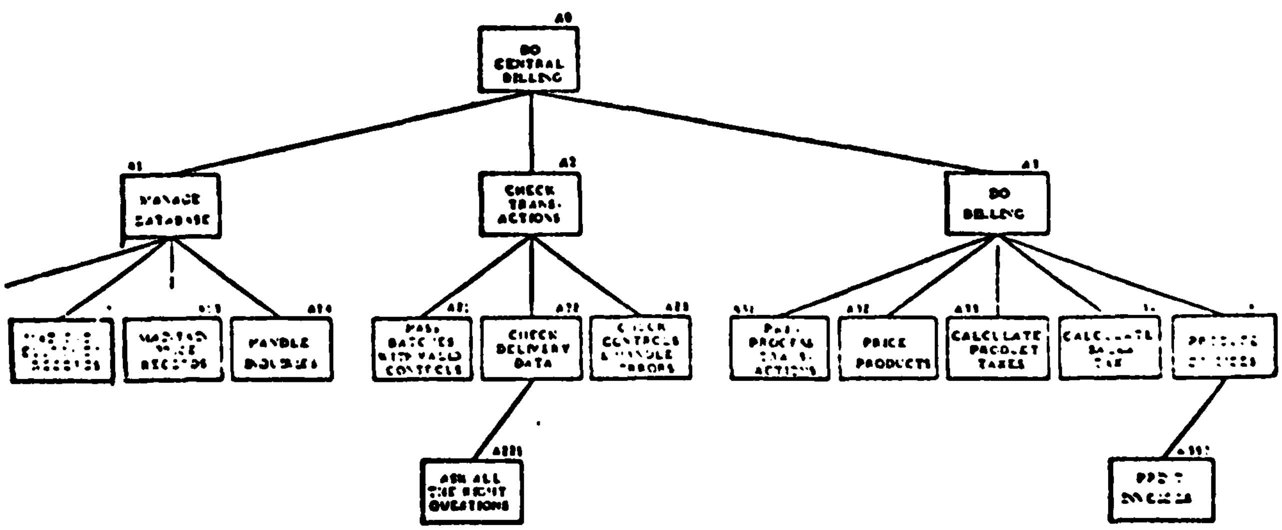
* "node number" and "C-number" are discussed later in this section.

## 4.3 The "Node" and "Title" Fields

When the diagram form is actually used to draw structured diagrams, referencing is based on the hierarchy of diagrams. The hierarchy is expressed by a node number for each diagram. By convention, the components of a diagram are shown as numbered boxes. Each box is detailed in a diagram at the next lower level, and so forth. If one were to spread out all of the diagrams, a structure like that shown below would appear. The place of each diagram is indicated by a node number, derived from the numbering of the boxes. For example, A21 is the diagram which details box 1 on the A2 diagram. Similarly, A2 details box 2 on the A0 diagram, which is the top diagram. This hierarchy may be shown in an index of diagram names and their node numbers called a diagram tree, if all diagrams are shown, or a node tree, if all box names are shown. The figure shown below is a typical tree. Each box in this tree represents a whole diagram.

A table of contents may also be formed by a node index. This is simply an indented list of the node numbers and titles of all boxes. Of course, the graphic language of diagrams provides much more information than either of these outlines alone.

The Title field may contain the name of a diagram and qualifying descriptors of any kind. If the Message field contains a diagram, then the contents of the Title field precisely match the name written in the corresponding high-level box.



## NODE INDEX AND CORRESPONDING DIAGRAMS

**Node Index**

**A -0** Gather Information (Context)

**A0** Gather Information

**A1** Coordinate and Monitor

**A2** Prepare for Interview

- **A21** Confirm Data
- **A22** Determine Eligibility
- **A23** Prepare Notifications
- **A24** Notify Unit and Member

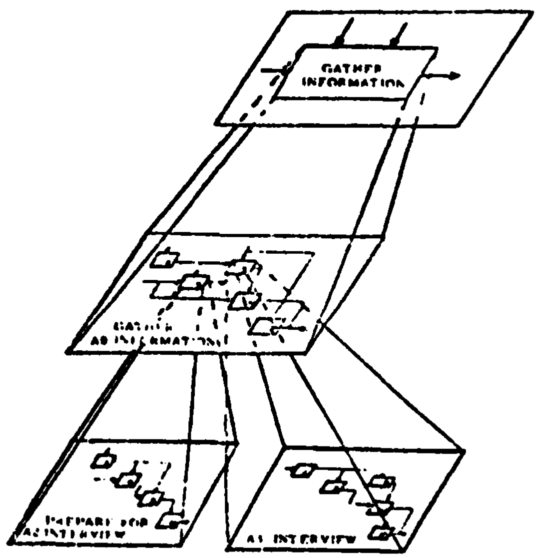
**A3** Interview

- **A31** Confirm Preparedness
- **A32** Instruct Member re Options
- **A33** Gather Member Choices and Data
- **A34** Prepare Forms and Instructions
- **A35** Instruct Member

**A4** Prepare Items

**A5** Perform Final Actions

**Corresponding Structure**



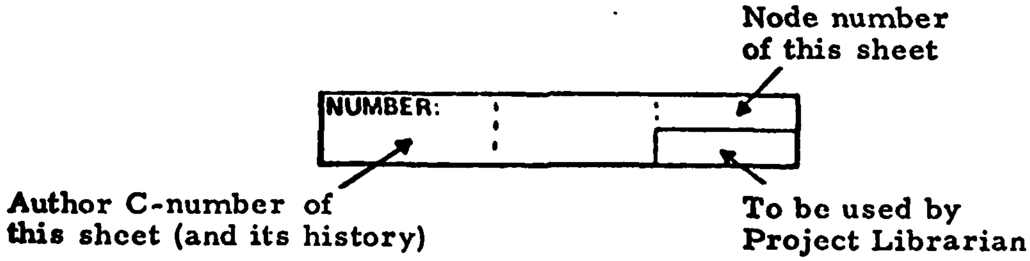
## 4.4 The "Number" Field

This field contains all numbers by which this sheet may be referenced. The most basic is the "C-number" or "creation number." The C-number is composed of two or three letters of the author"s initials, followed by a number sequentially assigned by the author. This C-number is placed in the lower left corner of the Number field, and is the primary means of reference to a sheet. When a model is published, the C-number may be replaced by a standard sequential page number (e.g., "pg 27").

If the diagram replaces a previous version of the same diagram, a second C-number is written in parentheses following the first C-number, to identify the replaced sheet. For example, if the Number Field reads "F158 (F124)," this says that F158 replaces the former F124 version of the diagram. This is used to show the complete revision history.

A reader kit page number may also be written by the librarian at the right hard side of the Number Field. This is composed of the document number followed by a letter identifying the sheet within the document, in alphabetical order.

The "node number," when presented, is found in the upper right hand corner of the Number field and is always given if the sheet contains a diagram or material related to a diagram (text, FEO, etc.). (Note that the node number appears twice: here in the NUMBER field and also in the NODE field, where it may also include a model name.)




In authoring an original sheet, only write as follows:

## The C-Number Log

The C-Number Log aids an author in assigning chronological sheet numbers. The Log prevents duplicating or skipping numbers, and provides a handy index of sheets used. The Log should be the first page in an author's project workbook.

An author begins a new C-number sequence at the start of each project. The first entry is the log sheet itself, sheet number 0. If needed, additional log pages will be numbered 100, 200, 300, and so forth.

For each new diagram form used, an abbreviated title (or the appropriate node number) may be written in the next available space on the Log. At the same time, the assigned number is written on the diagram form. Every diagram form should be identified with a sequential C-number.

Note that the Log is slightly more than a simple check-off. It indicates for what purpose each diagram form was used. And it provides a concise summary of all sheets used.

AUTHOR R. [illegible] DATE: 18 MAR 75
PROJECT: TDS

NOTES 1 2 3 4 5 6 7 8 9 10

C-NUMBERS STARTING AT RS 00

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 00 | C NUMBER LOG | 25 | | 50 | | 75 | |
| 01 | — Interview [illegible] | 26 | | 51 | | 76 | |
| 02 | E1 Glossary | 27 | | 52 | | 77 | |
| 03 | A0 Data List | 28 | | 53 | | 78 | |
| 04 | A0 OPERATE TDS [illegible] | 29 | | 54 | | 79 | |
| 05 | A-0 " " | 30 | | 55 | | 80 | |
| 06 | A0 " " (RS4) [illegible] | 31 | | 56 | | 81 | |
| 07 | A-0 " " (RS5) | 32 | | 57 | | 82 | |
| 08 | A0 " " (RS6) | 33 | | 58 | | 83 | |
| 09 | A3 [illegible] | 34 | | 59 | | 84 | |
| 10 | A2 Process [illegible] Entries | 35 | | 60 | | 85 | |
| 11 | A1 " " " [illegible] | 36 | | 61 | | 86 | |
| 12 | A1 Process Request | 37 | | 62 | | 87 | |
| 13 | A4 [illegible] | 38 | | 63 | | 88 | |
| 14 | Kit 2 Cover | 39 | | 64 | | 89 | |
| 15 | A0 Notes [illegible] | 40 | | 65 | | 90 | |
| 16 | | 41 | | 66 | | 91 | |
| 17 | | 42 | | 67 | | 92 | |
| 18 | | 43 | | 68 | | 93 | |
| 19 | | 44 | | 69 | | 94 | |
| 20 | | 45 | | 70 | | 95 | |
| 21 | | 46 | | 71 | | 96 | |
| 22 | | 47 | | 72 | | 97 | |
| 23 | | 48 | | 73 | | 98 | |
| 24 | | 49 | | 74 | | 99 | |

NODE: | TITLE: C-NUMBER LOG | NUMBER: RS 00

## 2.3 Personnel Roles

The roles and functions of people involved in the author/reader cycle are:

- **Authors** — People who design or analyze a system or create a document.
- **Commenters** — People who review kits and comment on them in writing.
- **Readers** — People who read documents for information but are not expected to make written comments.
- **Librarian** — A person assigned the responsibility of maintaining a file of documents, making copies, distributing reader kits, and keeping records.

In addition, the full process requires that the following roles also be identified:

- **Technical Committee** — Senior technical people assigned to resolve technical questions or disagreements, or recommend a decision to the project management. This will usually be in the form of a review meeting conducted by a coalition of senior area representatives, occurring either regularly (monthly) or as documents are readied for publication.
- **Experts** — People from whom authors obtain for information by means of interviews. Most experts are also asked to serve as commenters.
- **Project Manager** — The member of the project who has final responsibility for the finished product.

It is important to note that these are generic roles and that the author/reader cycle may be used at any time. The subject of a "kit" may be a plan, an analysis, a design, or a computer program. A "role" has nothing to do with someone's job title, and the same person may be asked to perform several roles. For example, one may be an expert and a commenter, or an author and a commenter (of others' work). Thus, each individual's participation in the project is, in fact, unique.

## KEEPING FILES

Each author and commenter will handle many diagram forms during the course of a project. It is not enough simply to have everything written on paper; one must also be able to find the papers and to relate them properly. Thus, the librarian, each author, and each commenter maintain files of documents. The librarian maintains the central master and reference files for the project. Each author maintains files showing current versions and the annotated sheets which record how they evolved. Each commenter keeps records of his interactions with authors.

The files of reader kits must permit easy access, while still maintaining the integrity of valuable master files. Variations in the filing process may occur at individual sites, but it is recommended that four files be maintained:

- Model Files, maintained by each author and commenter, contains the most current version of each document or model.
- Original File, maintained by the librarian. Originals are kept unbound in reverse chronological order.
- Reference File, maintained by the librarian, contains one archive copy of each document or reader kit. (In large projects, an Index File, of reader kit cover sheets only, may also be kept.)
- Extra Copies File, maintained by the librarian.

(Note: Do not remove the Original File or the Reference File from the library. Obtain copies from the Extra Copies File or by making a request for a copy to the librarian. The Reference File may be read by any project member.)

The "model files" maintained by commenters should be designed for convenient use. They should include reader kits (both in process and obsolete kits) and the most current version of the evolving document or model.

## 2.3 Boxes

When the boxes on a diagram represent activities, they are each described by an active verb phrase, written inside the box. Each box on a diagram is also numbered in its lower right corner, in order from "1" to at most "6."

The arrows that connect to a box represent real objects or information needed by or produced by the activity. They are each labeled with a noun phrase, written beside the arrow. "Data" may be information, objects, or anything that can be described with a noun phrase. The arrows are constraints that define the boxes, not just sequences or flows of activities.

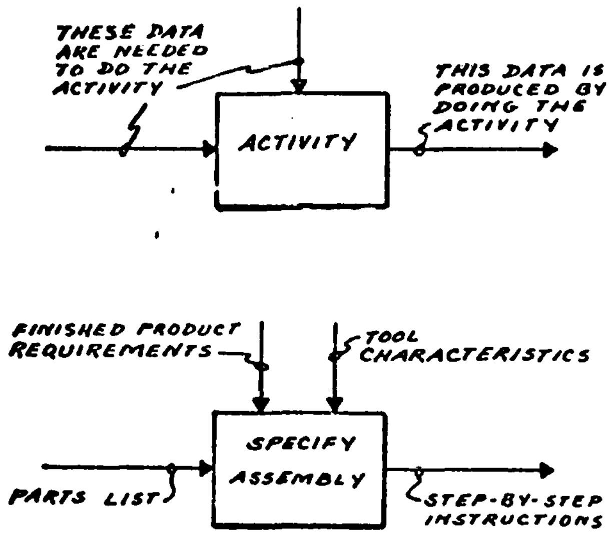
The side of the box at which an arrow enters or leaves shows the arrow's role as an input, a control or an output. Incoming arrows (left and top of box) show the data needed to perform the activity. Outgoing arrows (right of box) show the data created when the activity is performed. From left to right (input to output), an activity transforms data. An input is converted by the activity into the output (the input, in effect, "becomes" the output). The terms "input" and "output" convey the notion that a box represents a transition from a "before" to an "after" state of affairs.

A control describes the conditions or circumstances that govern the transformation. The roles of input and control are decidedly different. The distinction is important to understanding the operation of systems. The assumption is that "an arrow is a control unless it obviously serves only as input." Every activity box will have at least one control arrow.

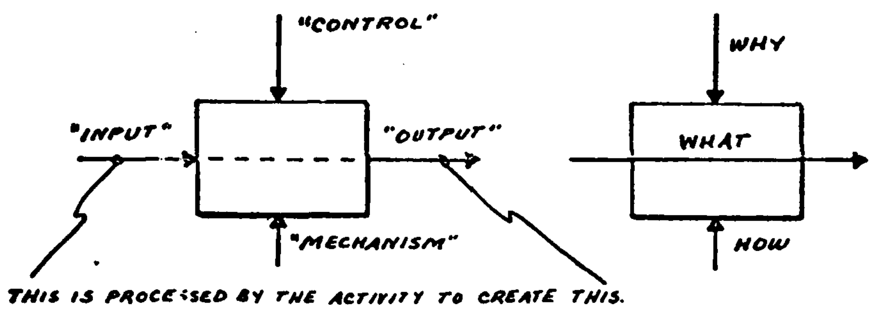
The bottom of a box is reserved to indicate a mechanism, which may be the person or device which carries out the activity. In summary, the input and output show WHAT is done by the activity, the control shows WHY it is done, and the mechanism shows HOW it is done.

Boxes represent collections of related activities, not just monolithic actions. A box may perform various parts of its function under different circumstances, using different combinations of its input and controls and producing different outputs. These are called the different activations of the box. There may be several arrows on any one side of a box.

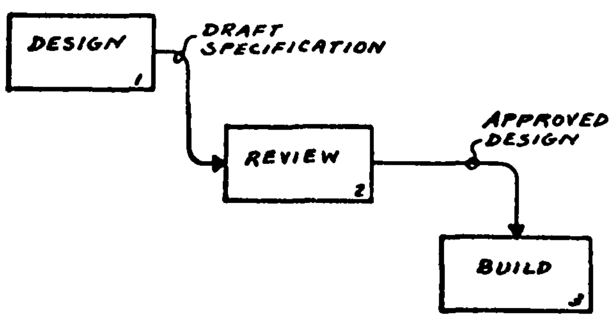
If it is unclear whether a particular word is a noun (data) or a verb (activity), an "(n)" or "(v)" may be appended to the word. For example, the word "Record" could mean a record, or the action of recording. "Record(n)" is used for the former case, and "Record(v)" is used for the latter.




ARROWS CLARIFY AND BOUND THE MEANING OF EACH BOX




EACH BOX REPRESENTS A TRANSFORMATION



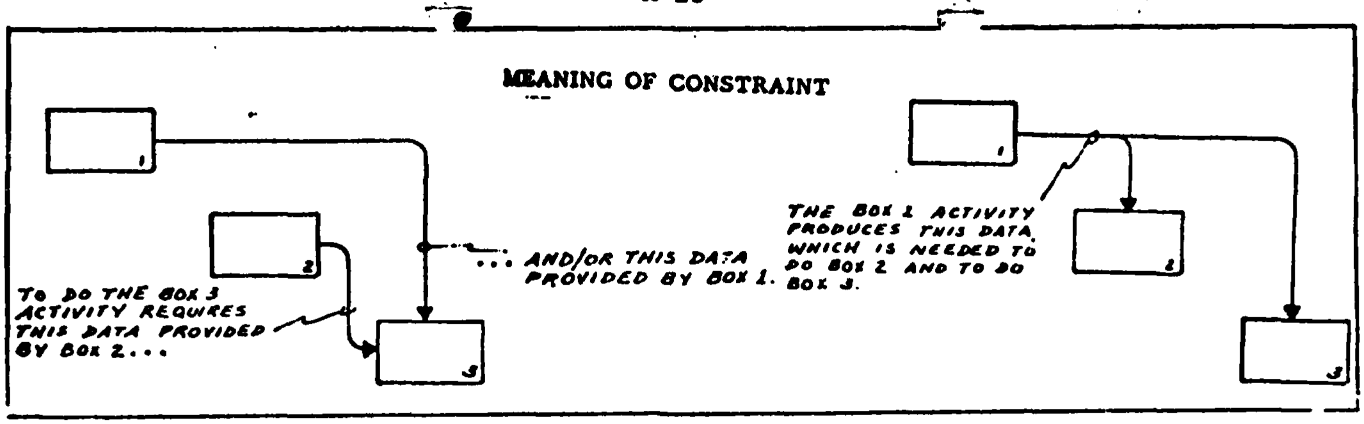

ARROWS CONNECT THE BOXES

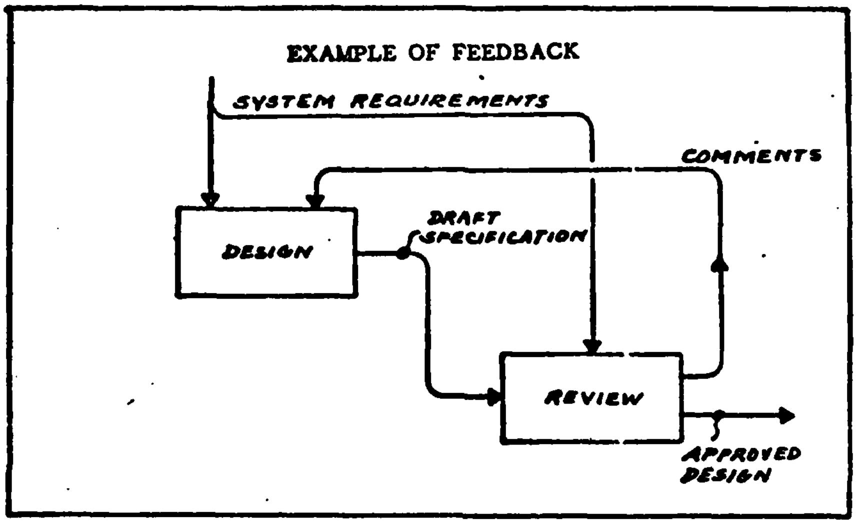
## 2.4 Arrows

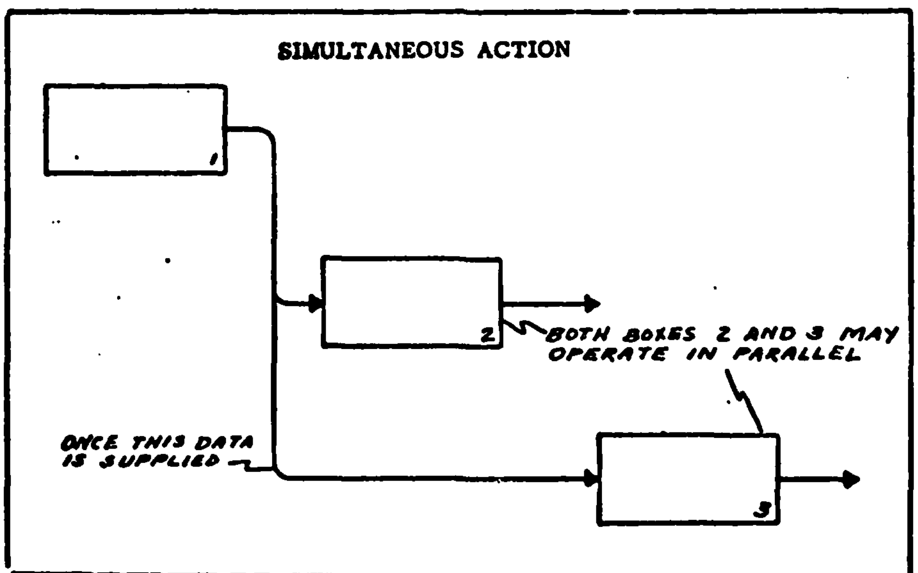
The arrows on an activity diagram represent data constraints. They do not represent flow or sequence. Connecting the output of one box to the input or control of another box shows a constraint. The box receiving the data is constrained, since the activity cannot be performed until the data is made available by the box that produces it. The arrows entering a box show all the data that is needed for the activity to be performed. Several activities on a single diagram could be performed simultaneously, if the needed constraints have been satisfied. Arrows connect boxes, and an output of one box may provide some or all of the data needed by one or more other boxes.

Neither sequence nor time is explicit in activity diagrams. Situations such as feedback, iteration, continuous processes, and overlapping (in time) activities are easily shown. This is possible because the arrows connecting to the left ("input") or top ("control") of a box are "constraints." That is, they represent data or objects needed to perform some part of the function. For example, a draft system specification submitted for review (see example opposite) may be approved and thus become final, or it may be returned with comments and with a request that a new draft be submitted. The latter causes a "re-do" of the design activity. Both the design and the review are done with respect to the system requirements.

In activity diagrams, arrows may branch (implying that the same data is needed by more than one activity) or they may join (implying that the same class of data may be produced by more than one activity). It is usually the case that more than one kind of data is needed to do an activity, and that more than one kind of data is produced by an activity. The branches may each represent the same thing, or different things of the same general type. The arrow labels make clear what the arrows are. On any given diagram, data may be represented by an internal arrow (both ends connected to boxes shown on the diagram) or a boundary arrow (one end unconnected, implying production by or use by an activity outside the scope of the diagram).


MEANING OF CONSTRAINT
1
2
3
TO DO THE BOX 3 ACTIVITY REQUIRES THIS DATA PROVIDED BY BOX 2...
... AND/OR THIS DATA PROVIDED BY BOX 1.
THE BOX 1 ACTIVITY PRODUCES THIS DATA, WHICH IS NEEDED TO DO BOX 2 AND TO DO BOX 3.

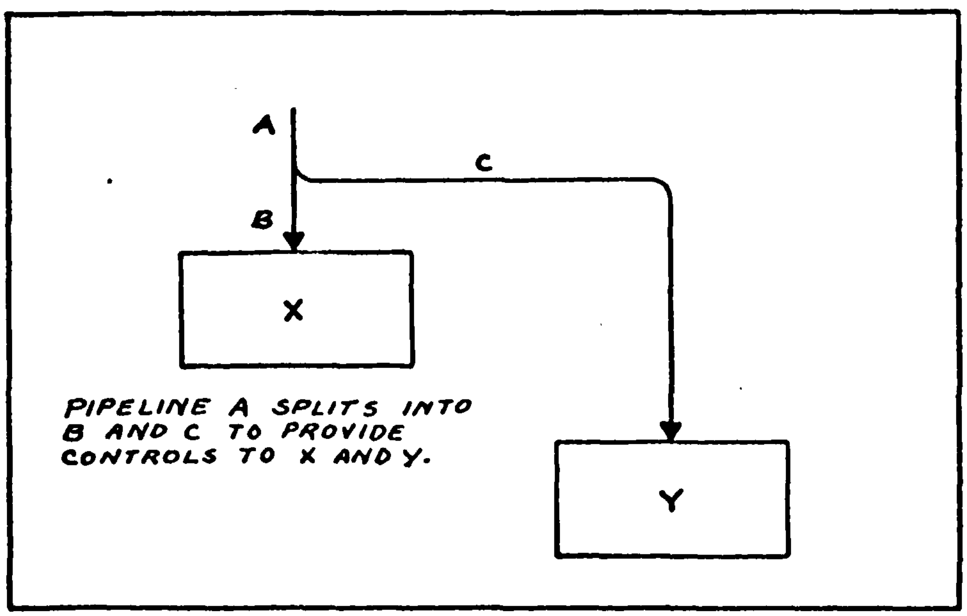

EXAMPLE OF FEEDBACK
SYSTEM REQUIREMENTS
COMMENTS
DESIGN
DRAFT SPECIFICATION
REVIEW
APPROVED DESIGN


SIMULTANEOUS ACTION
1
2
3
BOTH BOXES 2 AND 3 MAY OPERATE IN PARALLEL
ONCE THIS DATA IS SUPPLIED

## 2.5 Arrow Connections Between Boxes

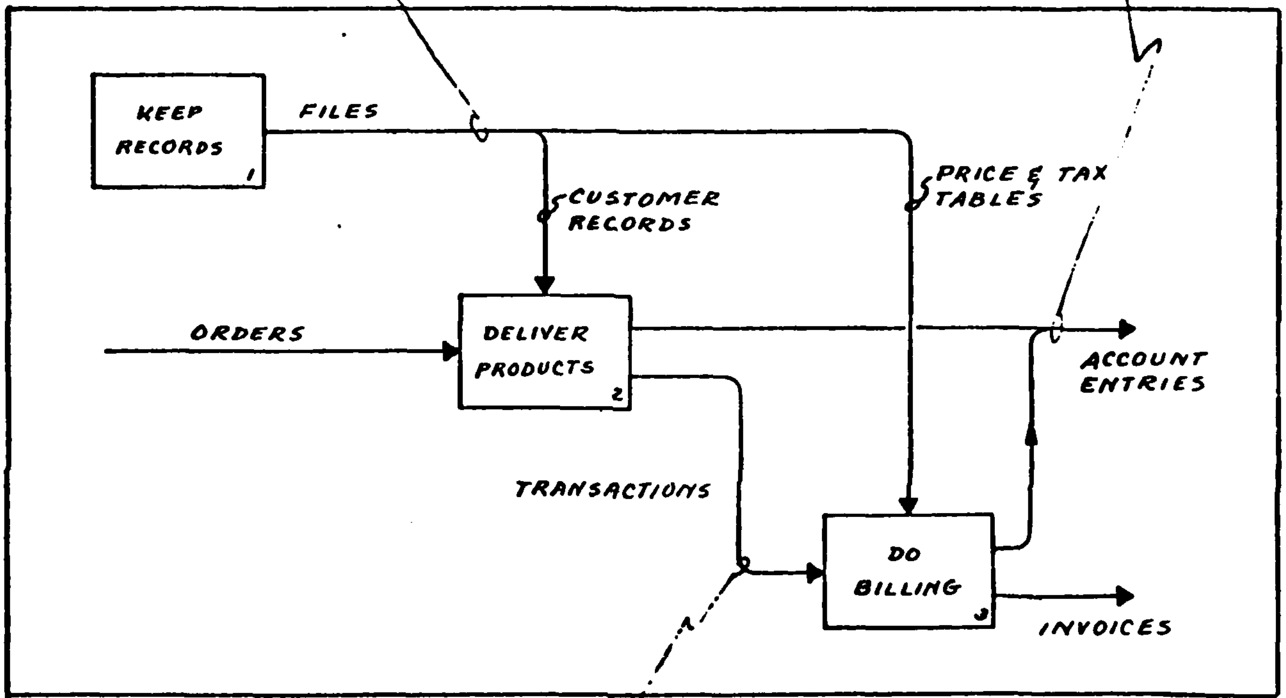
To form a complete diagram, from three to six boxes are drawn and connected by input, output, and control arrows. The boxes are a detailing of a single box on the "parent" diagram, and cover exactly the same subject matter as the parent box, in finer detail. Any output arrow may provide some or all of the input or control (or mechanism) to any other box. An output arrow may branch and provide data to several boxes. Arrows that are unconnected at one end represent data that is supplied or consumed outside the scope of the diagram.

All manner of arrow branches and joins are used to show box relationships. Data arrows, like activity boxes, represent categories. It is useful to think of high level data arrows as "pipelines" or "conduits." Such arrows, with general labels, may branch, each branch having a more specific label. In any case, the arrow labels must convey the author's intent to the reader. Using fewer arrows will reduce clutter, this making a diagram easier to understand. Using fewer arrows, while still conveying the message of the diagram, requires careful choice of meaningful words. The best use of structured analysis has both abstract and intense meaning at each level, even though details always are found at lower levels.



This branch means that "files" (produced by box 1) are composed of "customer records" (needed by box 2) and "Price and Tax Tables" (needed by box 3).

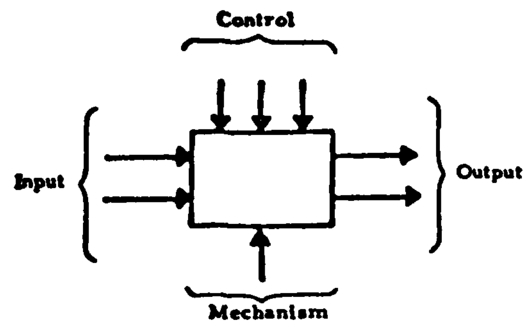
This join means that "account entries" are created by some from DELIVER PRODUCTS (box 2) and/or some from DO BILLING (box 3).




This chain of input and output arrows means that "orders," upon delivery (box 2), are recorded as "transactions," which, when billed (box 3), are reflected on "invoices."

## 2.6 Mechanism Arrows

If a box represents an activity, then input data (on the left) are transformed into output data (on the right). Controls (on the top) govern the way the transformation is done.




Mechanisms (on the bottom) indicate the means by which the activity is performed. A "mechanism" might be a person or a committee or a machine or a process. The box itself, with its inputs, controls, and outputs, indicates WHAT the system does. The mechanism shows HOW that activity is accomplished. Diagrams drawn without mechanisms show what functions a system must perform. Selecting specific mechanisms later will allow those functions to be implemented.

A downward-pointing mechanism arrow (known as a "call") indicates a processor that completely performs the function of the box. If there is a needed for further detailing, it will be found in a separate model of the mechanism itself.

Mechanism arrows may be the output of other boxes, if those boxes create or prepare processors (devices) from their inputs and controls. More often, however, a mechanism model is a separate portion of a multi-model analysis or design. (A discussion of such multiple models is beyond the scope of this document.)

# APPENDIX B

## <u>RELEVANCE TREE PAPER</u>

GRADUATE SCHOOL OF BUSINESS INDIANA UNIVERSITY | A Reprint from BUSINESS HORIZONS

WILLIAM L. SWAGER

# TECHNOLOGICAL FORECASTING IN PLANNING

## A method of using relevance trees

*William L. Swager is assistant manager, Department of Social and Management Systems at Battelle, Columbus Laboratories. Much of the material in this article is reprinted, by permission, from the author's series of three papers entitled "Strategic Planning" in* Technological Forecasting, *IV, Nos. 1, 2, and 3, 1972 and 1973.*

*Forecasting in the seventies, if it is to be effective, must include political and social considerations as well as the traditional technical and economic elements. The author describes a procedure using relevance trees that helps structure and partition forecasting issues in the planning process. The perspective-tree approach to the identification of threats and opportunities helps to reveal policy options at the level of broad business strategy. The author lists seven steps of the process, and points out that twenty-five or thirty such trees can usually be identified. The objectives trees clarify the program options. Levels of subobjectives need to be added for more detailed R&D planning.*

---

Technological forecasts are essential to the development of realistic strategic plans. However, many companies' efforts to use technological forecasting methods have been less than successful for two reasons: first, forecasts of social, economic, and political trends and events have not been sufficiently integrated with those of technological events and trends, and, second, the technological forecasting activity has tended to be divorced from either business or technical planning.

Dunckel, Reed, and Wilson of General Electric have argued convincingly that the political and social dimensions of forecasting must be added to the more traditional technical and economic if business planning is to be effective in the seventies.[1] Little is reported by these authors or others on how these kinds of forecasts can be creatively generated to circumscribe threats and opportunities for a particular business and how this kind of forecasting can be coupled closely with strategic business planning and related research and development planning.

This article describes a procedure using relevance trees that helps structure and partition forecasting issues in the planning process. It encourages the making of sets of related social, economic, and political forecasts as well as technological forecasts. This method also provides a model for information collection and communication among line-and-staff people involved in the planning process.

The procedures described here involve two kinds of relevance trees—perspective trees and objectives trees. No attempt will be made to describe the nature of these tree structures or

1. Earl B. Dunckel, William K. Reed, and Ian H. Wilson, *The Business Environment of the Seventies: a Trend Analysis for Business Planning* (New York: McGraw-Hill Book Company, 1970).

**TABLE 1**

**Steps in Development and Use of Perspective Trees**

1. *Define the business under consideration*
An identifiable portion of a business or technology of concern is the framework within which plans are being developed.

2. *Develop initial lists of relevant factors*
Factors are listed in two domains—environment, utilities and functions, and technology. The business is also characterized in terms of the functions and utilities of its products and services.

3. *Make an array using an initial categorization scheme*
Categories conceptually simple and germane to the business and/or technology are created.

4. *Fill gaps and identify new factors*
This step uses the categorization as a creative device to search for new and more meaningful factors.

5. *Assemble initial forecasts and purge array*
Each factor listed is implicitly a forecast. Make them explicit and, if possible, quantitative.

6. *Search for relationships and identify perspective trees*
This is a search for sets of changes in the environment that can be related to sets of changes in technology through the logic of the utilities and functions.

7. *Translate to specific threats and opportunities*
Each perspective tree represents an area of potential change. As such, each represents a threat or opportunity, depending on the present position of the company.

the concepts behind them.[2] Rather, step-by-step procedures are described that will reveal in a practical way how these structures provide an interlocking framework for forecasting and planning, emphasizing the creative identification of options at two levels: policy options at the level of broad business strategy, and program options at the level of functional and departmental tactics.

## PERSPECTIVE TREES: POLICY OPTIONS

A perspective-tree approach to the identification of business threats and opportunities is as much a process as it is a method. Different people—coming from R&D, marketing, or finance—see things "rightly" but from different points of view. The perspective-tree procedure provides a structured process by which their data and arguments can lead to judgments on strategy—the identification and ranking of threats and opportunities.

Using a perspective-tree approach to the identification of threats and opportunities involves careful selection of a planning team and a task force representing R&D, marketing, finance, and planning; scheduled work sessions and reviews with executive management; and a seven-step procedure. The members of the planning team and task force should be selected for their knowledge of the business and/or technology, their demonstrated creative approach, and their communicative skills. After being briefed on the approach, these people follow a seven-step procedure as given in Table 1.[3]

### The Steps

*Step 1. Define "the Business" Under Consideration.*—This initial definition emphasizes the question, "What business are you in?" as phrased years ago by Peter Drucker. The breadth of view given to the analysis is governed by the answer. In general, a business can be defined narrowly by the characteristics of its product, more broadly by what the product does, or still more broadly in a generic class. Examples of the three types of definitions are as follows:

Narrow: Writing instruments, electric automobiles, wallpaper
Intermediate: Business communications, urban transportation, wall coverings
Generic: Communications, transportation, interior wall systems.

If thought is given to the definitions at various levels, a few days effort at most would

2. For further information on perspective and objective trees see W. L. Swager, "Strategic Planning II: Policy Options," in *Technological Forecasting and Social Change*, No. 3, Vol. IV (1973), and "Strategic Planning III: Program Options," No. 4, Vol. IV (1973).

3. For a more detailed description see Swager, "Strategic Planning II and III."

## TABLE 2

### Forces of Change in the Paper Industry

*Social, Economic, and Political Environment*

EPA regulations
Costs of capital
Increasing labor costs
$No_x$ standard, 100-250 micrograms/$m^3$
Solid waste
Air Quality Act of 1970
Odor standard
Paper imports
GNP
Demand for recycling
$SO^2$-$SO^3$ standard, 80-350 micrograms/$m^3$
Federal guidelines for water
State regulation
Suits against paper mills
Investment cycle in paper industry
BOD in effluents
Color in effluents
Electronic communications
Demand for paper
Return on capital in the paper industry

*Technology*

Closed system for process water
Improved instrumentation
Nonwood natural fibers
New sheet forming processes
New pulping processes
Dry bleaching
Electrostatic precipitators
Waste-paper pulping
Use of cryogenics for condensing gaseous pollutants
Synthetic fibers
Multi-mini computer control
Continuous digesters
$NH^3$ pulping
Fluidized-bed recovery systems
K-number sensing

## TABLE 3

### Functions and Uses of Products in Paper Industry

| *Uses* | *Product* |
|---|---|
| Communications | Printability |
| Packaging | Cost |
| Construction | Availability |
| Health | Basis weight |
| | Surface |
| | Brightness |
| | Recycled fiber content |

| *Process* | *Control* |
|---|---|
| Digestion | Meet standards |
| Washing | Reduce chemical consumption |
| Bleaching | Reduce effluents |
| Recovery | Increase capacity |
| Pape making | Increase yield |
| Conv rting | Reduce labor |
| | Reduce energy |
| | Increase uniformity |
| | Reduce downtime |
| | Increase safety |

be required to decide on an initial definition. During the course of the analysis the initial definition can be modified as deemed appropriate.

*Step 2. Develop Initial Lists of Relevant Factors.*—The purpose of this step is to break conventional patterns of thinking by getting several small groups together to consider the possible forces of change that would have an impact on the initially defined business. A process similar to that of brainstorming is used except that the effort is to identify relevant social, economic, political, and technological changes rather than solutions to a problem. A typical group may include a manager, an engineer, a physicist, a social scientist, a marketing man, and a chemist, selected partially from the task force and partially from elsewhere in the company. The forces of change that should be considered in an analysis of the paper industry include those listed in Table 2.

During these group sessions, an indirect approach is used to characterize the business. Answers to the following questions are listed: What functions does the product serve? How are they measured? What are the tangible and intangible attributes of the product considered to be of value by the user? Again in a study of the paper industry, the functions and utilities of the products that help characterize the business are listed (see Table 3).

*Step 3. Make an Array Using an Initial Categorization.*—The lists of initial factors in the environment domain include broad aggregate terms such as EPA regulations, electronic communications, and gross national product, and micro terms such as $NO_x$ standard: 100-250 micrograms per cubic meter, paper

TABLE 2

Forces of Change in the Paper Industry

| Social, Economic, and Political Environment |
|---|
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| Costs of capital |
| Increasing labor costs |
| $No_x$ standard, 100-250 micrograms/m$^3$ |
| Solid waste |
| Air Quality Act of 1970 |
| Odor standard |
| Paper imports |
| GNP |
| Demand for recycling |
| $SO^2$-$SO^3$ standard, 80-350 micrograms/m$^3$ |
| Federal guidelines for water |
| State regulation |
| Suits against paper mills |
| Investment cycle in paper industry |
| BOD in effluents |
| Color in effluents |
| Electronic communications |
| Demand for paper |
| Return on capital in the paper industry |
| ***Technology*** |
| Closed system for process water |
| Improved instrumentation |
| Nonwood natural fibers |
| New sheet forming processes |
| New pulping processes |
| Dry bleaching |
| Electrostatic precipitators |
| Waste-paper pulping |
| Use of cryogenics for condensing gaseous pollutants |
| Synthetic fibers |
| Multi-mini computer control |
| Continuous digesters |
| $NH^3$ pulping |
| Fluidized-bed recovery systems |
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| ***Process*** | ***Control*** |
| Digestion | Meet standards |
| Washing | Reduce chemical consumption |
| Bleaching | Reduce effluents |
| Recovery | Increase capacity |
| Papermaking | Increase yield |
| Converting | Reduce labor |
| | Reduce energy |
| | Increase uniformity |
| | Reduce downtime |
| | Increase safety |

During these group sessions, an indirect approach is used to characterize the business. Answers to the following questions are listed: What functions does the product serve? How are they measured? What are the tangible and intangible attributes of the product considered to be of value by the user? Again in a study of the paper industry, the functions and utilities of the products that help characterize the business are listed (see Table 3).

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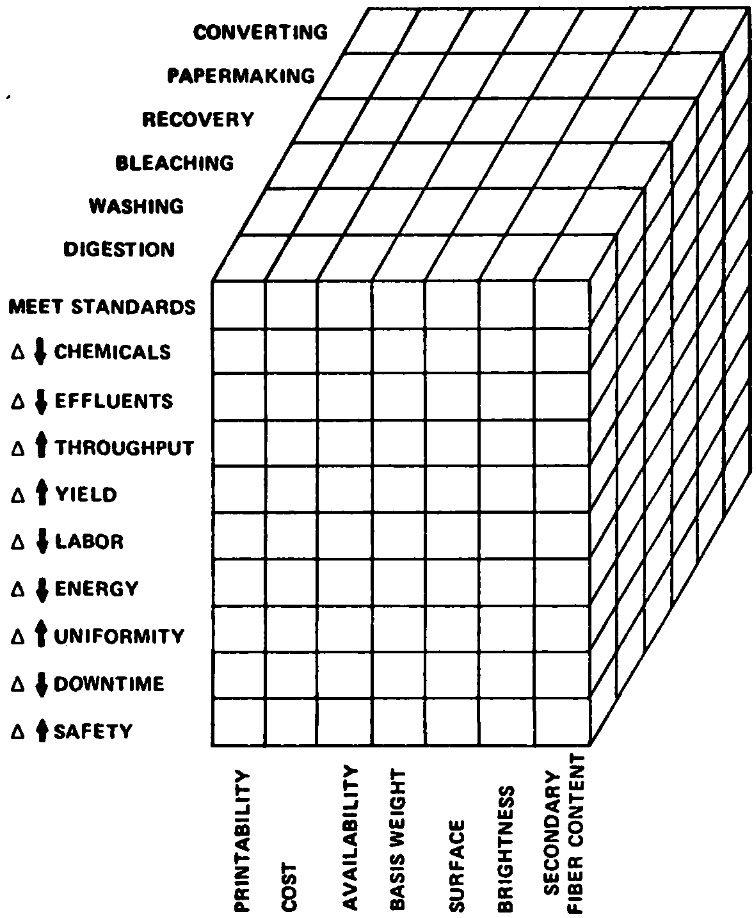
FIGURE 1

A Characterization of the Communications Paper Business




imports, and costs of capital. As a means of searching for more precise terms for which relevance can be postulated, a systematic categorization of the initial lists is undertaken. The mechanics of this step are facilitated by preparing a 3x5 card for each factor.

Various ways of categorizing cards are explored during which addition of factors becomes obvious. For example, all of the factors dealing with EPA might be placed under the broader heading of "Ecology"; "Electronic communications" may be considered a heading for facsimile, cable TV (two-way), telephone, and business use of TV. Which of these affect the paper business and how? When a reasonable categorization is found, the terms are arrayed on a wall-size sheet of paper. Similarly, the technologies presently and potentially involved in paper are categorized and arrayed.

Our experience in working with this type of analysis shows that first thoughts on how to categorize are not necessarily the most useful. This is particularly true of the domain dealing with the characterization of the business. There are many facets of a business to be represented. As an example, one way to visualize the paper business would be to use the four dimensions of the paper business indicated previously. Because of the limitations of graphic presentation here, I have chosen to indicate in Figure 1 how the part of this domain might be structured for one of the major uses—say, communications papers.

A characterization of the business as indicated in the figure can be considered as multidimensional impact space. Changes in the environment and in technology have an impact on various cells. In Step 6, the environment and technology domains will be

scanned relative to each cell individually for significant changes affecting that cell.

*Step 4. Fill Gaps and Identify New Factors.*—This and the next two steps, although described in a sequence, are accomplished in part in parallel and involve several iterations. Review of the array by specialists and recategorization of portions of the array bring to light new factors.

*Step 5. Assemble Initial Forecasts and Purge the Array.*—Most people—executives as well as managers—tend to expand the array during the previous step. More and more factors are added, cluttering the array and obscuring the analysis.

In the previously presented list of environmental factors for the paper industry, GNP and demand for paper were listed separately. The projection of demand for paper was derived from a historical relationship to GNP and a projection of GNP. Until one can postulate a different relationship or a different projection of GNP, one or the other of these "forecasts" can be dropped from the array. We would drop the GNP forecast, adding it to the list of factors deleted from the array with the reason given.

Preliminary forecasts are made for all of the factors in the environmental and the technological domains. For example, synthetic fibers were listed in the technological domain. A synthetic fiber can produce technically a usable paper. What other forecasts are needed to establish the likelihood of significant use of synthetic fibers? What methods of forecasting are applicable? Only recently, domestic petroleum refiners and petrochemical companies have recognized that growing demand for feedstock and limited supplies will put pressures on price. What are reasonable forecasts of availability and cost of petrochemical feedstocks and demand for feedstocks from plastics, synthetic fiber, lead-free gasoline, and sulfur-free fuels?

Such forecasts, translated to fiber costs and compared to the forecasts of wood fiber costs, including pollution controls, provide a basis for judging whether synthetic fibers may be a threat to the paper industry as now constituted—or an opportunity for polymer producers. In a recent study, synthetic-fiber technology was purged from the array as an unlikely event in the next ten to fifteen years—and probably longer. It was not dropped and forgotten, but was put in a list of factors eliminated from the array for reason.

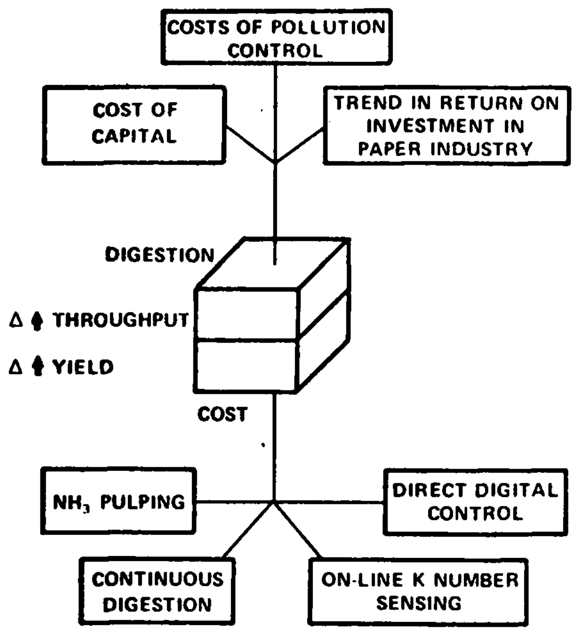
*Step 6. Search for Relationships and Identify Perspective Trees.*—There is a temptation to immediately state significant relationships previously recognized. The above steps, however, have set the stage for a systematic cell-by-cell search for sets of forecasts in the environment and of technology that are related to each other and to one or more cells. The diagram of such a search represents a perspective tree. Small groups, composed of members of the core team and the task force, go through the cell-by-cell search for relationships.

An example of a perspective tree identified in such a procedure is given in Figure 2. This tree states the following relationships that might be considered a miniscenario: forecasts of the costs of capital in the foreseeable future are going to be substantially higher than they have been in the past. Return on investment in the paper industry began dropping more than ten years ago and has not been at a satisfactory level since. Added investment will be forced on the paper industry from pollution control regulations. These forces in combination make the two cells noted—increased throughput and increased yield in digestion—much more urgent than they have been heretofore.

Forecasts of potential technical advances in new pulping processes, continuous digestion, direct digital control, and instrumentation of K number (a measure of the completion of digestion) hold promise for increasing throughput or yield. Environmental forces are consonant; this is an area of likely change. Figure 2 represents only one of many perspective trees that can be drawn, linking related environmental and technological changes through one or more cells. Each represents a potential threat or opportunity.

**FIGURE 2**

**Example of a Perspective Tree Isolated from the Array**




The individual trees, however, may or may not be significant until translated into their likely impacts on a particular company.

*Step 7. Translate to Specific Threats and Opportunities.*—The significance of the environmental forces and related technological forces noted in Figure 2 differs depending on a company's present position.

For paper companies, this could be a threat or an opportunity, depending on the strength of the company's process engineering and control systems staffs

For paper equipment and machinery manufacturers, this could be a threat if weak in control-systems technology

For control systems manufacturers, this could be an opportunity for new market penetration.

## Deciding on Changes in Strategy

Experience with perspective-tree analyses demonstrates that twenty-five or thirty such trees can usually be identified. Each of these sets of environmental and technological changes represents a threat or an opportunity. By policy a management group can choose to respond or not. The obvious question is how a rational priority can be established among such threats and opportunities.

The perspective-tree analysis does not in itself provide a basis for establishing priority because it includes no information or judgments on the internal environment of the company. It provides no quantitative approach to the ranking and ordering of priorities among the threats and opportunities that have been identified. It merely makes more explicit and elucidates the forecasts that were involved, the nature of likely change, and the likely impacts on the business. This provides a framework for management to arrive at a realistic ranking of priorities.

Executives who understand the internal environment of their company can now consider the potential threats and opportunities.

*1. The Nature and Degree of Impact on the Business and the Probability of Occurrence.*—Some threats could have tidal-wave impacts on a business. Those future events having high probabilities of occurrence usually involve modest to negligible impacts, and those having low probabilities of occurrence are usually associated with major to catastrophic impacts. This usual situation of impacts and probabilities running in counter-directions increases the chances and significance of potential errors in forecasts or their interpretation.

Management judgment is essential to assessment of the interaction of a complex set of contingencies implicit and explicit in the forecasts. If a management group cannot reach agreement on priorities among the threats and opportunities, the perspective tree provides a clear framework for developing additional data and making refined forecasts using a variety of methods in order to help develop a consensus. In such a case, however, the constraints in terms of time and cost are clearly defined by the planning process.

*2. Timing.*—Partially explicit in each of the perspective trees is the mechanism of

change—a sequence of trends and events, each related to time. Management judgment of timing is also essential in establishing priorities. Certain of the events are related sequentially in time, and others are concurrent. Forecasts of the timing of impacts may be judged in relation to the inertial forces of a system.

Some systems involve large inertial forces such as the infrastructure associated with automobile transportation. A major change in the vehicle—even involving a different power plant and fuel, such as a turbine—would have a gradual impact on the petroleum industry and precipitous impact on, say, carburetor manufacturers. If all new automobiles coming off the assembly lines of the world, beginning tomorrow, had turbine power plants, the changeover period for the petroleum industry would be more than ten years. The carburetor manufacturer would face an immediate drop in his new-car market and would be limited subsequently to a dwindling aftermarket.

The point here is that sets of forecasts may involve different inertial forces, and the timing of the threat they describe is not necessarily controlled by any one of them, but by their interaction. Here again the emphasis is on developing sets of forecasts and, if possible, using different methods of forecasting.

3. *Reaction Time.*—Also associated with each of the threats and opportunities is an estimate of time required for appropriate action. The time required varies substantially from industry to industry and from one threat or opportunity to another within an industry.

Reaction time is related to the characteristics of the industry involved as well as to the nature of the threat. The reaction time of the petroleum industry to a diminishing market for one of its most highly refined products and an increase in others is not easily estimated. The mix of crudes now being used, the type and location of refineries, and the worldwide transportation network for crudes and refined products are the result of an evolution to meet the current mix in demand for refined products. A certain amount of flexibility in the present system provides for adjusting to a changing mix of refined products. Beyond that, major changes in the physical facilities at refineries would be needed, which may require years for design and construction.

The characteristics of the apparel industry, on the other hand, enable this industry to react quickly to changes in design as well as in fabrics. One executive commented, "A few years ago considerable effort was made to forecast the length of women's skirts. A great controversy in the management group of our company developed over the accuracy of the forecasts. The connotation of the words 'accuracy of forecast' became meaningless when women began wearing pantsuits rather than dresses. Our ability to react quickly, however, allowed us to succeed in spite of misleading forecasts." There are four design cycles per year; therefore, any forecast of design features more than six months ahead is irrelevant. The time required to react to change is usually less than six months.

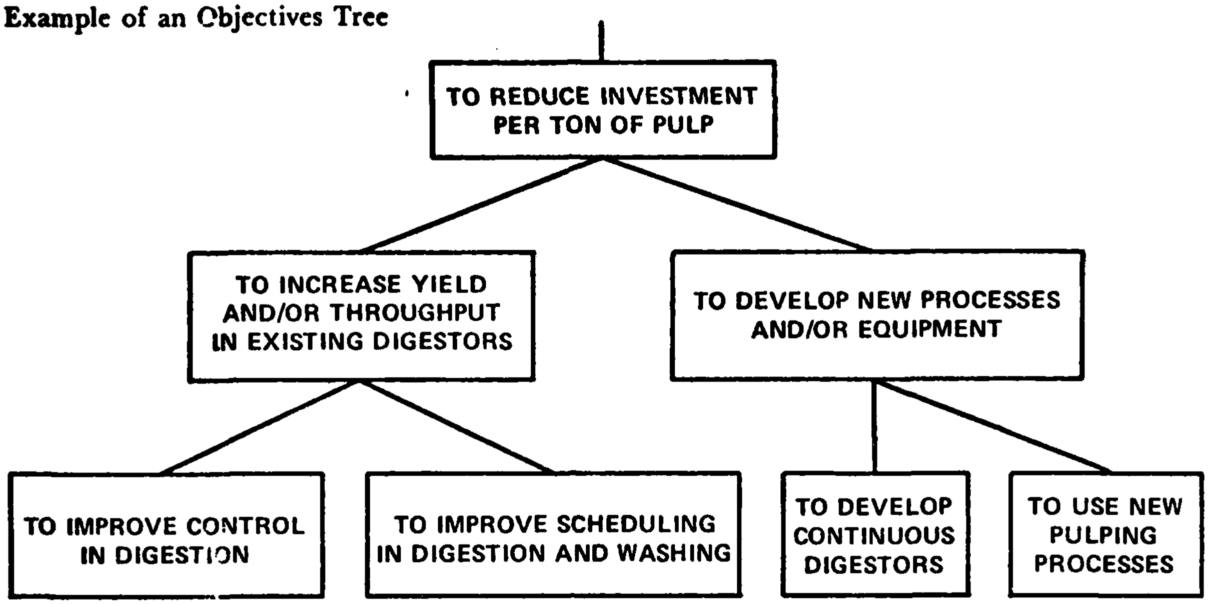
Judgments of reaction time weigh heavily in establishing priorities regarding the several threats and opportunities facing a company. Management's experience in judging that reaction time is an important input.

4. *Threshold of Effective Effort.*—This is probably one of the most difficult of management judgments to be made in assessing priorities on threats and opportunities. At this stage, only partially defined alternatives are available to counter threats or take advantage of opportunities. Thus only order-of-magnitude estimates are available on the amount of effort required. Here again, management judgments are essential in considering priorities relative to resources.

The perspective-tree analysis in itself provides a major increment in improving management's ability to reach consensus. It recognizes that all of the forecasts are conditional, and these are presented with the realization that management must base judgment on the conditions surrounding each. The procedure helps eliminate errors of

FIGURE 3

Example of an Objectives Tree




omission and provides specific sets of forecasts and guidance for the establishment of priorities.

## OBJECTIVES TREES: PROGRAM OPTIONS

If the management of a paper company judges the forces of change depicted in Figure 2 to be a threat or opportunity, what are its options for responding? First, a strategic objective related to this threat (or opportunity) is "to reduce investment per ton of pulp." There are environmental factors making this objective more important than it has been in the past, and there are technological potentialities for achieving it. Alternative ways of accomplishing that strategic objective are partially structured in the objectives tree given in Figure 3. Succeeding levels of subobjectives need to be added for more detailed R&D planning.

The adding of such detail involves the creative identification of options at each node at each level. The tree itself provides a communications vehicle for explaining to technical specialists the options already identified and the strategic objectives behind them. This framework has proved to be a stimulus to creative identification of additional options.

When the lower level objectives are added, the completed tree provides R&D management with alternative paths from which to choose. If more detailed forecasts are needed to judge the relative merits of competing paths, they can be made within realistic time and cost constraints. The structure of an objectives tree, of course, by appropriate intuitive "pruning" could be transformed to a decision tree for final R&D budgeting. In our experience, this refinement has not been necessary or practical.

As in all forecasting and planning, "success" depends in great measure on top management commitment, concern, and involvement and participation by middle management and staff groups. Of course, what is successful and what is not is a subjective judgment. We judge our efforts as successful when they clearly identify threats and/or opportunities that had not been seen before, or identify new technical approaches to old problems. In both cases, creativity and judgment of people brought to light new options. The relevance trees merely structured thinking and communications.

# APPENDIX C

## PRE- AND POST-SESSION QUESTIONNAIRES

PRE-SESSION QUESTIONNAIRE

Name__________________________ Organization__________________

1. Please place a check mark next to the number of formal group sessions you have participated in within the last three years.

   ☐ a. None

   ☐ b. 1 or 2

   ☐ c. More than 2.

2. Have you ever led a group using a formalized group dynamics technique?

   a. Yes_______________ b. No_______________

   If yes, which technique(s) did you use?

   ____________________________________________________________________

3. Have you previously used the scenario approach to planning?

   a. Yes_______________ b. No_______________

4. Did you participate in the preparation of the bubble or aggregation charts?

   a. Yes_______________ b. No_______________

5. Are you familiar with the Long Range Planning process being developed through XRB?

   a. Yes_______________ b. No_______________

6. Are you familiar with the LAG methodology being used to describe the AFLC functions?

   a. Yes_______________ b. No_______________

7. Have you previously participated in a brainstorming session?

   a. Yes_______________ b. No_______________

8. Have you previously participated in a brainwriting session?

   a. Yes_______________ b. No_______________

9. Have you previously participated in the Nominal Group Technique process?

   a. Yes_______________ b. No_______________

10. Briefly state your expectations for attending this meeting.

11. Please characterize your decision style, acknowledging the fact that most people adapt their decision style to different circumstances, and may actually be best represented by a mix of styles. Number from 1 to 4, with 1 being your most dominant decision style, and 4 the least used.

____ The Decisive Style

The Decisive Style is seen as one prizing speed, efficiency and consistency. Just enough data is used to generate an adequate decision. Decisions are made quickly with few backward glances.

____ Flexible Style

Flexible Style shares the decisive habit of focus on solution. This style uses minimal data but sees solution as changing consistently over time. It however relies more on intuition than facts.

____ Hierarchic Style

Hierarchic Style is the style which strives to attain the best solution. Rigor extends to method as well as results.

____ Integrative Style

Integrative Style shares the high data bias of the hierarchic but generates multiple solutions rather than one. It is a style which likes information for its own sake and seems most creative.

# POST-SESSION QUESTIONNAIRE

Name____________________ Organization____________________

In the following statements, please indicate your feeling or attitude by placing a check mark in the appropriate box.

Example

"Computerized data processing is necessary to the modern organization."

| Strongly disagree | | | | | X | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

1. I found the planning task rewarding.

| Strongly disagree | | | | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

2. The introduction presentation defined what was expected of me.

| Strongly disagree | | | | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

3. The recommended process will be useful in the AF environment.

| Strongly disagree | | | | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

4. I understand how the planning process begun here will affect my organization's need for new data systems.

| Strongly disagree | | | | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

5. It was easy to present my views using the brainstorming technique.

| Strongly disagree | | | | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

6. I was satisfied with the brainstorming technique.

| Strongly disagree | | | | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|---|

7. I recommend using the brainstorming technique for future sessions.

Strongly disagree | | | | | | | | Strongly agree

8. It was easy to present my views using the brainwriting technique.

Strongly disagree | | | | | | | | Strongly agree

9. I was satisfied with the brainwriting technique.

Strongly disagree | | | | | | | | Strongly agree

10. I recommend using the brainwriting technique for future sessions.

Strongly disagree | | | | | | | | Strongly agree

11. It was easy to present my views using the nominal group technique.

Strongly disagree | | | | | | | | Strongly agree

12. I was satisfied with the nominal group technique.

Strongly disagree | | | | | | | | Strongly agree

13. I recommend using the nominal group technique for future sessions.

Strongly disagree | | | | | | | | Strongly agree

The following statements are aimed at describing your personal decision style.

14. My personal decision style is primarily intuitive and implicit as opposed to analytical and explicit.

Strongly disagree | | | | | | | | Strongly agree

15. I try to look mostly at the immediate short term, near-at-hand consequences of a choice. I do not get involved in looking way ahead into the distant future.

Strongly disagree | | | | | | | | Strongly agree

16. As a decision maker I am creative and experimental as opposed to habitual, conventional, and routine.

Strongly disagree | | | | | | | | Strongly agree

The following statements are aimed at evaluating the mechanics of the session.

17. The seating arrangement for the small group sessions was conducive to idea exchange.

Strongly disagree | | | | | | | | Strongly agree

18. The visuals used in the presentations were effective.

Strongly disagree | | | | | | | | Strongly agree

19. The facilitator in the small group sessions was effective.

Strongly disagree | | | | | | | | Strongly agree

20. The material, received in the mail prior to the planning session, was very useful.

Strongly disagree | | | | | | | | Strongly agree

21. I was satisfied with the overall Planning Session.

Strongly Disagree | | | | | | | | Strongly agree

22. Briefly discuss the features of the session that you like the best.

23. Briefly discuss the features of the session that you like the least.

## High Level Guidance Items

1. Impact of energy shortages
2. FMS workload impact on AFLC support of USAF readiness
3. Identifying weakest logistics links to Air Force war fighting capability
4. Desirability of increasing NATO interoperability
5. Hardening and increased security of AFLC management information capabilities
6. Level of detail required for management at HQ AFLC
7. Desirability of interservicing
8. Examples of possible logistics weak links include in theater air lift, in theater POL storage capacity, and rapid runway repair equipment
9. Identification and awareness factors limiting logistics ability to meet readiness surge
10. Training for logisticians
11. Zero warning time action plans at ALC
12. Required to show long range LMS and ADP replacement plans firmly based on mission needs analysis
13. Turkey is key to NATO
14. More contractor use of organic facilities within depots
15. Meaningful management indicators for management system
16. Improving wartime planning functions
17. Actions for handling hazardous materials
18. Action for meeting OSHA regulations
19. Contractor surge capabilities
20. LMS capabilities directly support USAF forces, friendly nations and other federal agencies

21. Timely response to contingencies

22. Information for making informed decisions affecting readiness

23. Methods for prioritizing support

24. Improvement of material

25. Meeting logistics requirements at the lowest possible cost

26. Planning, budgeting and accounting of AFLC resources

(Addendum to Scenario Format Task 4(b))

## Descriptors That Will Be Important Drivers In The Proposed Scenarios

| Descriptors, Driving the Scenarios | State of Descriptors in Scenarios | | |
|---|---|---|---|
| | A | B | C |
| **Descriptors With States Varying From One Scenario to the Next** | | | |
| World energy supplies | ↓ | → | ↑ |
| World Non-fuel mineral supplies | ↓ | → | ↑ |
| Fiscal control by congress | ↓ | ↑ | ↑ |
| Government regulation | ↑ | → | ↓ |
| Strength of environmental and health and safety movements | ↓ | → | ↑ |
| **Descriptors With Constant States** | | | |
| 1980's Workforce | ↑ | ↑ | ↑ |
| 1980's Supply of experienced managers | ↓ | ↓ | ↓ |
| 1990's Workforce | ↓ | ↓ | ↓ |
| Technology of weapon systems | ↑ | ↑ | ↑ |
| Civil/military logistics infrastructure | ↑ | ↑ | ↑ |
| Number of countries in NATO | ↓ | ↓ | ↓ |

## STIMULATING TOPICS
## FOR THE
## BACK POCKET

1. DLA takes over management of all small parts for DoD
2. Interservicing increases significantly
3. DoD takes over management of all logistics support
4. USAF directs the establishment of two-tier maintenance for most systems
5. Number of ALC's is reduced
6. Foreign contractor maintenance increases
7. U. S. contractor maintenance increases
8. U. S. establishes unified armed services with unified logistics command
9. Prepositioning is increased (decreased)
10. USAF begins extensive manned space flight operations
11. USAF acquires a large number of simple manned weapons systems
12. USAF weapons system mix tends toward one-time use weapons
13. AFLC incorporates use of NATO Standard Stock Number
14. Due to U. S. isolationist policy, FMS workload is drastically curtailed

## TASK $5(a)_N$: EXPECTED TYPES OF ANALYSIS OF NEEDS

### Pre-Requisites for Determining Types of Analysis

In the LMS planning process, there are two aspects that must be analyzed. The first is the content of the planning material generated in the planning session; the second is the technique used in developing that content. In each planning session the requirements for analyses are different. The following sections will deal with the two parts of the first planning sessions, namely the Policy Planning and Needs Planning, and the evaluation of the techniques to be used for each. An overview of the overall LMS development process, from Policy Planning through Data System Design, is shown in Figure 1.

### Policy Planning Session

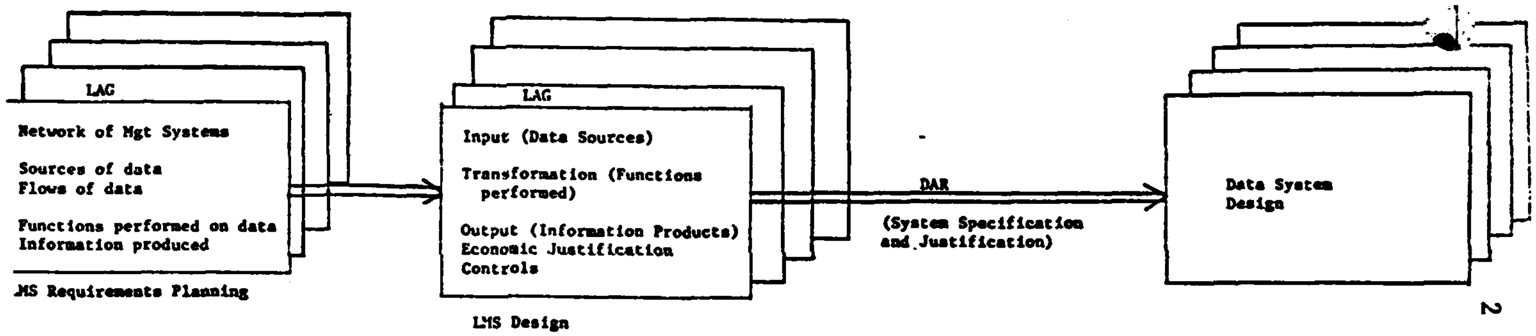
To provide a planned approach to LMS development, long range planning must begin at the logistics management policy level. Top level AFLC managers will consider the alternative future (scenarios) to which they may have to respond, and determine the management information that they will need. Readiness to respond to contingencies is of prime concern. Once wartime management needs are satisfied, consideration will be given to the alternative peacetime environments. The combined effect of these considerations may have a variety of impacts on ALC operations.

The consideration of these future scenarios leads to the development of management policy and a concept of logistics management. In turn, this logistics management (LM) concept when contrasted with current capabilities results in the definition of LM needs upon which LMS needs and an LMS concept can be developed.

The purpose of the policy planning session, therefore is to:

- o Establish a War Readiness Philosophy for LM Planning
- o Establish a Logistics Management Concept
- o Identify major impacts on logistics operations and LM of the combined theme and war scenarios.

To judge the accomplishment of these objectives it is recommended that a systems approach to analyses be performed. The following steps must be performed to do so:




IAGEMENT SYSTEMS DEVELOPMENT STAGES

1) Define the significant inputs
2) Identify the transformation process
3) Define the outputs
4) Identify the required controls
5) Identify the mechanisms at work.

Figure 2 illustrates the flow of information required to support the various planning sessions.

For this process the following inputs have been identified:

- o Consolidated Guidance War Scenarios
- o Battelle developed theme scenarios
- o LAG concept presentation
- o Related AFLC planning documents
- o Understanding of Process/Perspectives.

The following outputs should result:

- o War Readiness Philosophy for Logistic Management
- o Impact of the scenarios on LMS processes/perspectives
- o A Logistic Management Concept.

In addition to these outputs, the scenario inputs and the LAG concept must be confirmed for use as planning framework in subsequent planning sessions.

War Readiness Management Philosophy for LM Planning

This should be a succinct statement of overall objectives developed for managing AFLC under the conditions specified by each war scenario. These overall objectives will be further expanded in the Needs Planning session. They must be clearly stated, achievable, and measurable.

Impact of the Scenarios on Processes/Perspecitves

The output of this effort should be a matrix constructed to show the impact on each of the processes and perspectives by each of the scenarios, both war and peace. The information will be cross-tabulated so that all the effects of a particular scenario can be identified, and all the impacts on a given process or perspective can be assessed. The listing by scenario will be used as the source document for developing an audit trail of proposed Needs for the system. The grouping by process will identify all Needs so that solution designs can be coordinated.

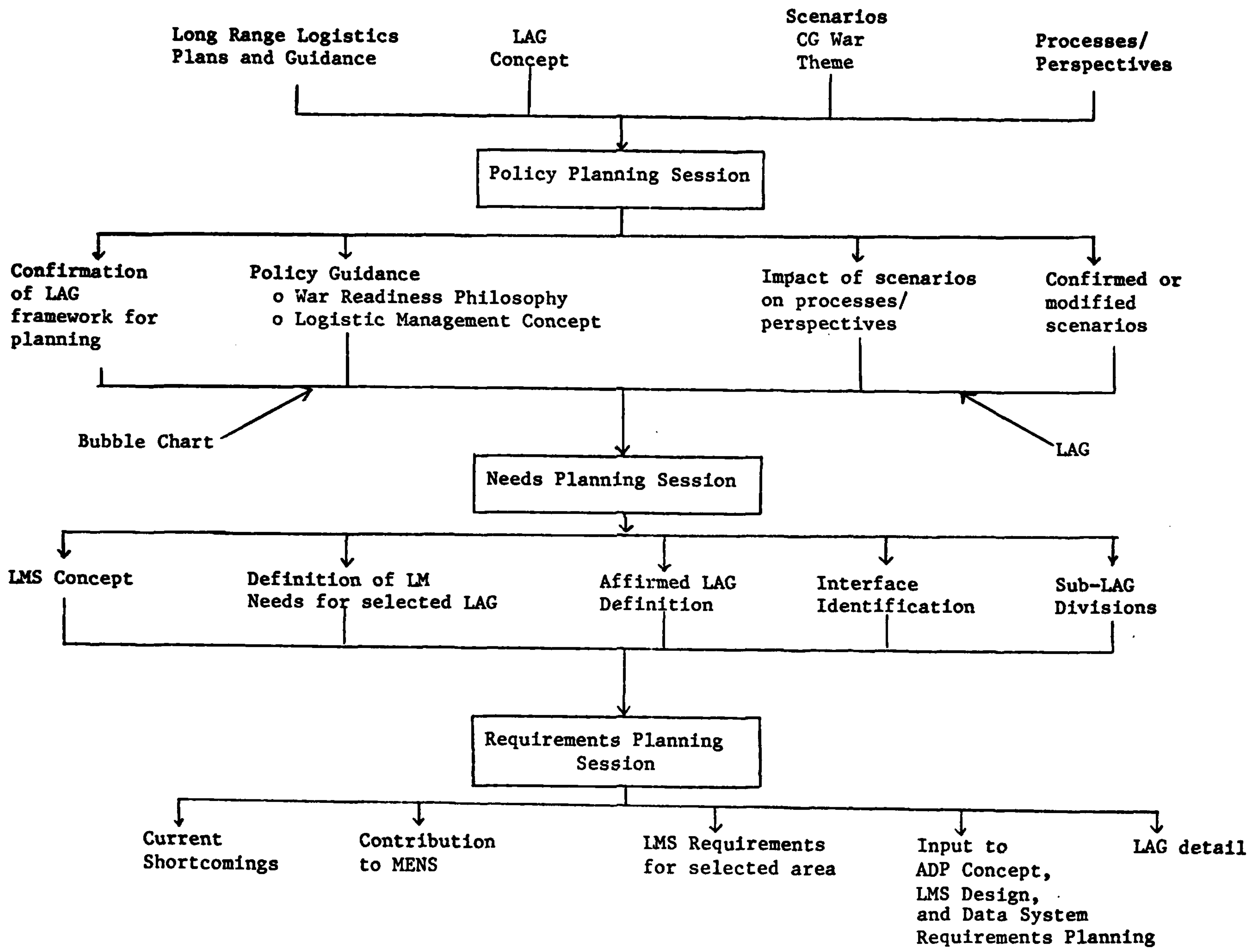



FIGURE 1. INFORMATION FLOW AT PLANNING SESSIONS

Logistic Management Concept

The heart of a logistics management concept is a description of how the logistics operations of AFLC are to be managed. This description is organized by logistics process and by other considerations. For our initial sessions, the emphasis is on the strategic level, although some consideration is given to the directive level and even to the operating level for emergency/surge actions.

The elements of the descriptions are:

(1) Decisions that must be made to manage the logistics process/other consideration.

(2) Data needs and analytical capabilities needed to evaluate alternatives.

(3) General sources for the needed data.

(4) General organizations to implement the decision.

There is no need to include:

(1) The LMS design required to provide the data needs.

(2) Specific organizational units to supply data or implement decisions.

(3) Detailed requirements and specifications for data quantities, flows, response times, accuracy, etc.

It is important that the Logistics Management concept provide a basis for ongoing steps leading to the implementation of an LMS. Omissions might lead to the need for major modifications during the operation of the LMS. Too much detail will lead to wasted time and effort in implementing LMS. Unnecessary elements might lead to unnecessary capabilities built into the LMS. Experience will be required to strike the optimum balance between too much and too little.

The decisions that must be made are part of a structure that include decisions all the way from strategic decisions made by the Commander AFLC to job assignments made by foreman in the warehouse and maintenance facilities at the ALCs. These decisions are made by many different people and can only be identified by people at the appropriate levels. Therefore, the complete logistics management concept cannot be developed in a single session. The overall series of policy, needs, and requirements sessions will produce a complete Logistics Management Concept including all three levels. The complete

LM concept could be expanded to show the structural relationships among the decisions.

The complete LM Concept contains some information in addition to the description of how AFLC is to be managed. The additional information defines the planning policy (e.g. the planning scenarios, acceptance of the planning approach) and the implementation policy (e.g. organization, responsibilities, support for ongoing planning). The LM Concept provides the foundation for LMS planning.

## Policy Planning Results Analysis

The initial analysis of output from this session will be done before the session adjourns, so that participants will have the opportunity to approve these efforts as input to the subsequent Needs Sessions. A hierarchical structuring will be used to trace the future expansion of these inputs at subsequent levels, and an iterative review process established, since feedback from lower levels may require further definition of prior concepts.

Some of the techniques being considered for the analysis at this level include cognitive mapping and relevance trees, which will be discussed in a later deliverable.

## Needs Planning Session

The purpose of the Needs Session is to address the implication of the selected approaches from the policy sessions on the LAG(s) selected for analysis as candidates for an "early start".

In order to do so the following inputs are required:

- War Readiness Philosophy in LM planning
- Impact of the scenarios on LMS processes/perspectives
- The Logistics Management Concept
- Consolidated Guidance War Scenarios
- Battelle developed theme scenarios
- LAG concept understanding
- Bubble chart for area
- Description of topics and associated LAG's.

Session staff representing AFLC upper management and missions (with emphasis on staff knowledgeable of the LMS incorporated in the selected LAG) will use these inputs to define in more detail how to meet upper management's information needs for managing the selected topics. The perspectives will be future oriented; that is, they will address how the information needs should be met so as to provide the information required to manage the functions incorporated in the selected topics under the conditions described by the scenarios. The expected output should be a definition of LMS needs that would be satisfied by a redesign of the LMS incorporated in the associated LAG's.

The specific outputs to be generated include:

- o Decision rules resulting from the application of the LM concept to the selected LAG
- o Affirmation or modification of the LAG definition
- o A list of interfaces with other LAG's
- o Recommendation of the area of the LAG to be further developed in the scheduled Requirements Session(s).
- o Contributions to an LMS concept* for specific processes related to topic areas.

## Needs Planning Results Analysis

Preliminary documentation of the results of this session must be made available to participants in the prior session, those in attendance, and those to be attendnig the related requirements session.

The hierarchical structure begun after the Policy Session will be expanded, and effects related to specific scenarios will be coded to maintain the audit trail.

Some of the techniques considered for this session include the ICAM Definition Method (IDEF) being used in the Air Force's Integrated Computer Aided Manufacture (ICAM) program, and the Q Sort Procedure for prioritizing projects.

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* See Attachment Number 1.

## Group Methods Analysis

A combination of lecture and group participation techniques will be used to stimulate the development of a futures approach to identifying needs. In order to recommend a format for subsequent meetings, it will be necessary to evaluate the techniques as to their usefulness.

Some of the factors that will affect the usefulness of the techniques selected are:

- The individual participant's background and perspectives e.g., his expectations, familiarity with the technique, and training or education.
- The make up of the group itself
- The organizational background
- Environmental factors.

All of these will act upon the group process and affect the process outcome.

To measure process outcome, such criteria as the quality of ideas generated, the quantity of ideas, the time required to complete the process, the immediate perceived satisfaction of the participants, and the traceability of the developed logic must be considered.

In addition to the process, the effect of the physical setting, and the role of the facilitators, will also be evaluated.

The techniques being considered for this area include before and after attitude testing; a questionnaire comparing the various techniques, and observations documented by facilitators, observers, and volunteer participants.

Attachment Number 1

## LMS CONCEPT

The term "LMS Concept" has been used by the AFLC/BCL team for some time. The term has not yet surrendered to an acceptable definition, nor consequently to consistent usage. This section is an attempt to provide at least a basis for definition that will lead to both a complete definition and consistent usage.

One way of developing a definition is by describing properties characteristic of a concept or object. In the case of "LMS Concept" we are interested in defining the functional role of the LMS Concept in the overall process of evolving new logistics management systems and in describing how the LMS Concept is portrayed. We also need to define the principles upon which the LMS Concept is founded and the implications of building upon those principles. In the following few paragraphs, each of the above properties will be described in an attempt to at least bound the definition of the term "LMS Concept".

### Functional Role of the LMS Concept

The LMS Concept is a framework for portraying how logistics processes are managed. The framework has two basic dimensions; management level and logistics process area. This is, of course, the framework developed for developing Logical Application Groups (LAGs). This framework allows one to portray the management system functions and information flows necessary to manage logistics functions at each level of management.

The content of the framework can be varied. The framework can be used to portray graphically the "existing" LMS concept. To do this the aggregation chart is arrayed across the appropriate levels of management. It is already ordered by logistics process. Such a portrayal with today's set of LMS will reveal considerable sparcity at the upper management levels.

This portrayal also provides the basis for identifying logic clusters and LAGs. These elements are the basis for synthesizing new management systems to replace or supplement existing LMS. The gaps revealed in the framework indicate process areas for which management does not have current visibility through LMS.

Another way of filling in the framework is to portray various types of management systems -- automated, manual and informal by developing each type separately. Through overlays, the interactions amongst different types of systems can be graphically demonstrated and consideration given to changing from one type to another in the future.

While the framework provides the basis for portraying LMS changes, and indeed can be developed to portray in total how the set of LMS would interact some years in the future, it also provides the basis for evaluating the impact of changes that are proposed from outside of a centralized LMS planning activity (i.e. from bottom-up requests for LMS). The effects of such proposed changes on both the existing LMS concept and the planned future concept can be readily evaluated because, using the framework, the interactions amongst LMS are visible. The impact of proposed changes on both current and planned systems can be readily seen by drawing the management interface boundaries and examining the impacts of proposed LMS changes. In particular, changes that change LAG boundaries are notable. In effect the changes imply changes in the evaluation of the criteria upon which the LAGs have been developed. Such changes must be carefully examined to determine whether they are really warranted. The value of the framework is that it makes visible the changes and their implications. Thus it provides the basis for managing configuration control of the set of LMS and consequently of the LMS concept itself. In this sense the LMS concept is both self-regulating and self-updating.

Implicit in the use of the LMS concept is a commitment on the part of AFLC and Air Staff to continually update the set of LMS and their supporting hardware. This process may require many years from planning for renewal of a particular LMS until that LMS comes up for renewal again. This must be clearly understood and accepted. Application of the concept also implies

that all LMS changes must be consistent with the LMS concept. This is fundamental to configuration control of the set of LMS. Nevertheless, it implies that new organizations may need to be established or existing organizational roles expanded to assure a consistent process of planning, conceptualization, design, development and implementation of LMS.

Careful consideration must be given to designing the organizations responsible for the process steps suggested above. Clearly, LO, MA, AC, SC and XR should all be involved. The question of how their participation can be smoothly developed in coordination with their existing functional responsibilities merits study.

Another aspect of the LMS concept and its use is its relation to A-109 and other regulations that impact system development. The LMS concept provides the foundation for evaluating and spinning off LMS projects. The planning leading to an LMS project definition is viewed as prior to the system development steps defined under A-109. The output of the planning would lead to a project definition suitable for initiating the A-109 process.

## Principles Underlying LMS Concept

The LMS concept is based on the principles that: (1) the AFLC logistics system consists of processes that are fundamental to logistics and (2) the management structure of AFLC is hierarchical in nature. That is, the basic dimensions of the framework are assumed to be fundamental and complete.

It is also assumed that planning activities underway at both XRX and XRB and the products of the Policy Planning Session will lead to an accepted "Logistics Management (LM) Concept". This is distinct from an LMS concept but provides the foundation for it. The LM concept includes the definition of planning policy (e.g. acceptable planning scenarios, committment to an evolutionary, incremental process of LMS renewal, etc.), definition of management information needs under various AFLC operating conditions ranging from peace to full wartime operations, definition of organizational roles, authorities, and responsibilities in LMS development, and committment of the resources required to support a permanently continuing process of LMS evolution.

The LMS concept is also based on the principle that it is only one element, albeit a controlling one, among the elements necessary to evolve new or updated LMS. The output of the LMS concept is definition of unfulfilled management needs or partially fulfilled needs requiring augmentation. This output feeds the elements of LMS requirements definition, LMS design, Data System design and LMS implementation in terms of ADPE/T conceptualization, design and acquisition. The result is new or augmented LMS that meet those management needs on the most appropriate ADPE/T equipment.

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